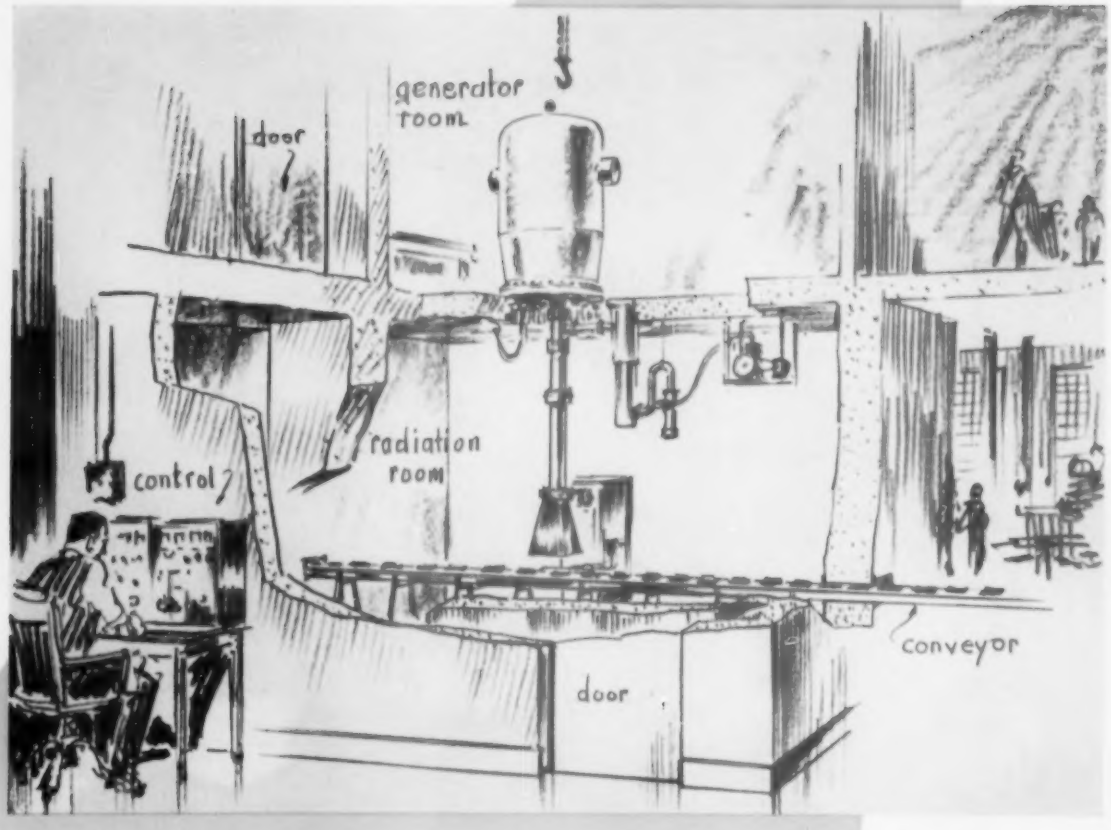
AUGUST, 1958
Vol. 12, No. 8

FT

food technology

food processing with ionizing radiations



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IN THIS ISSUE—

THE TECHNICAL ARTICLES IN BRIEF

Spoilage indicators *Fresh water fish*

Changes in the total volatile reducing substances and bacterial count as indices of fresh water fish spoilage. M. N. Moorjani, J. R. Iyengar, K. Visweswariah, D. S. Bhatia, and V. Subrahmanyan.

Determination of spoilage in fresh water fish by means of the VRS method together with bacterial counts, organoleptic judgments and chemical values has been studied. The various procedures as spoilage indicators are evaluated. (See page 385)

Methodology *Sampling method for surveys*

A sampling method for household surveys. I. Panel recruitment for testing wines. F. Filipello, H. W. Berg, and A. D. Webb.

Objective of this procedure was to obtain two probability samplings of families, 25% of whom were regular users of wine and all of whom had a yearly income between $3,000–$10,000. A pretest was employed to determine size and number of mailings necessary to obtain the required panel. Two cities were used as locales: Woodland and Sacramento, California. The panel was recruited by a double mailing to a random sample of families. Nearly all families eligible for the panel responded to the double mailing, with practically all of the non-response due to transiency or unwillingness to participate. For Woodland, a simple random sampling was used; in Sacramento, on the basis of known population characteristics, a proportionate, stratified random sample was taken. It was found that the percentage of 'active' (actual return of recruiting card by a respondent) response was about the same in both cities, although Woodland had a higher proportion of letters returned unclaimed. It was also found that response to mailing increases with areas of increasing economic level; that the first mailing tends to draw a higher proportion of general users of wine; that both the type of recruiting letter and agency have an effect on response. (See page 387)

Methodology *Fly egg counts*

Method for fly egg counts in tomato products. Charles D. Buss.

The conventional A.O.A.C. method has been modified to include a preliminary enzyme digestion of the tomato material. Filtration and counting are facilitated and the recovery of eggs improved. (See page 391)

Preserve manufacture
Effect of different sweeteners

Some effects of sweeteners on frozen fruits used for preserve manufacture. A. H. Bockian and M. Aref.

Effects of different sweeteners and fruit: sugar ratios on quality of Marshall strawberries, Montmorency cherries and Elberta peaches frozen for subsequent manufacture into preserves were investigated. Results show that ratios affect drained weights, that certain treatments affect the flavor and color of some thawed fruits and their preserves, and that there is no clear-cut evidence for the superiority of any sugar in these respects.

A large student taste panel failed to confirm previous indications by a small panel that Marshall strawberries capped with sucrose and frozen for 6 months yielded better flavored preserves. Fruit packed without sugar and frozen for periods up to 8 months and then processed into preserves had a color and flavor equal to those of preserves made from sweetened packs. (See page 393)

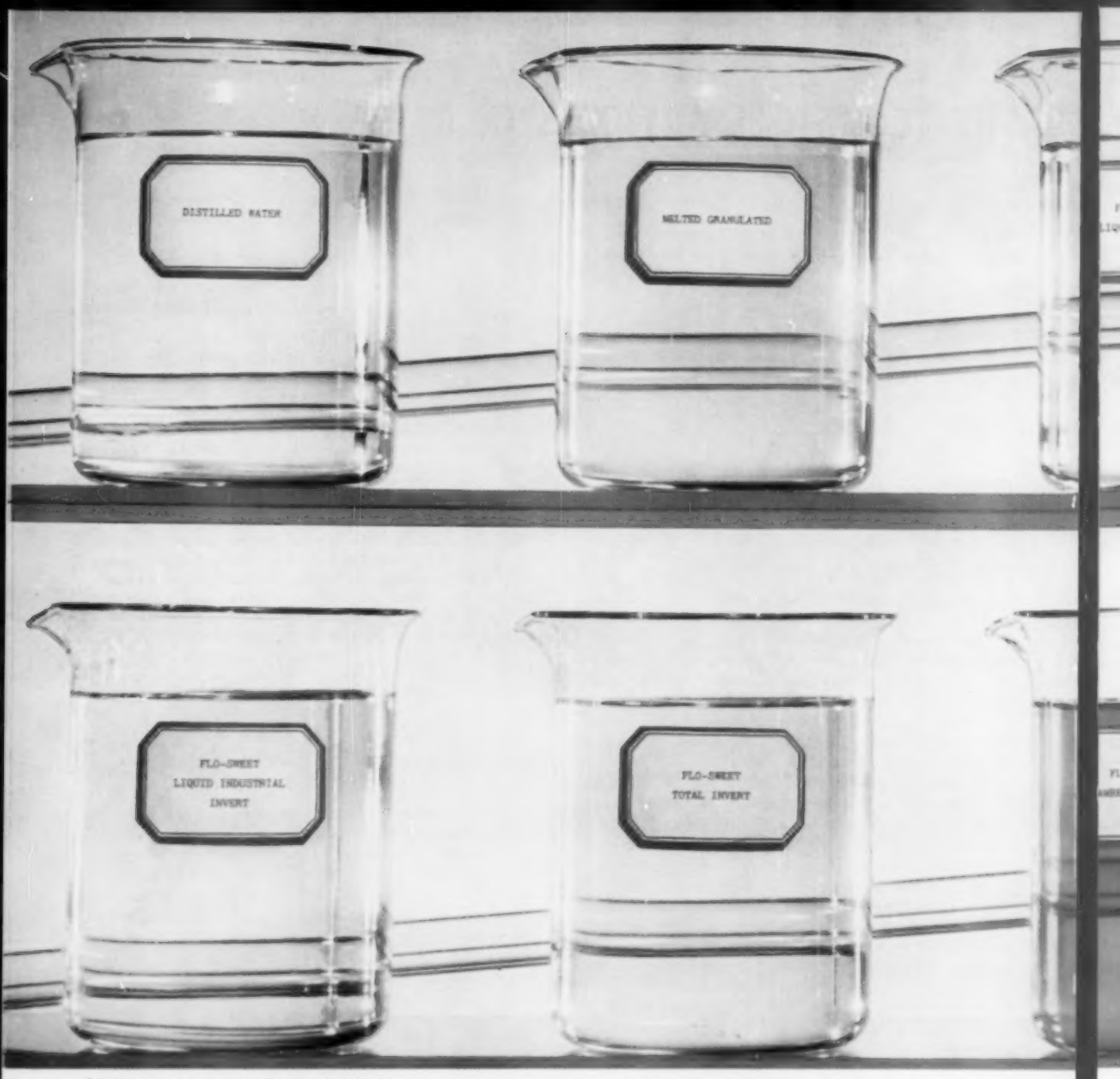
Freeze drying *Cooked meat*

Dehydrated cooked meat products. R. M. Ballantyne, C. Brynko, A. J. Ducker, and W. R. Smithies.

Typical cooked meat items can be freeze-dried in about 4 hours using spiked heater plates to ensure efficient heat transfer during the dehydration process. Pressure cooked meats rehydrate rapidly but products cooked by dry heat rehydrate with more difficulty when fat and connective tissue are present. Hot-air dried cooked ground beef is an acceptable item and rehydrates quickly. There appears to be little or no advantage in freeze-drying this type of product. (See page 398)

AUGUST COVER. The cover cut, an artist's concept of a typical installation for cathode ray irradiation of foods and food products, has historical significance. This drawing was used in an article by B. E. Proctor and S. A. Goldblith, which appeared in FOOD TECHNOLOGY for September, 1951. The drawing (courtesy, the Department of Food Technology, Massachusetts Institute of Technology, Cambridge) depicts a 2-story arrangement with the generator on the second floor, the treatment area on the lower floor. Food is passed under the beam on a conveyor belt.

HERE'S PHOTOGRAPHIC PROOF



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Color measurement

Comparison of instruments

On color measurements of foods. Angela C. Little, C. O. Chichester and G. Mackinney.

By applying statistical methods to the results obtained with a series of colored papers on a number of instruments, including 5 spectrophotometers and 3 tristimulus photoelectric colorimeters, high significant linear relations between all instruments studied were obtained. Regression equations were calculated for each attribute of color for each instrument against an arbitrarily chosen reference spectrophotometer. In this way, results from a series of vegetable purees whose reflectance characteristics were measured on 3 different makes of colorimeter were placed on a comparable basis. Agreement was obtained within the standard deviation. (See page 403)

Dehydration

Actomyosin as measure of damage

Effects of dehydration on actomyosin in fish and beef muscle. Sheila M. V. Hunt and N. A. Matheson.

Effect of dehydration on actomyosin in beef and cod muscle has been studied by following changes in solubility and contractility measurements on muscle fibres. As adenosinetriphosphatase is so intimately linked with actomyosin, change in enzyme activity also offered a means of measuring damage to this protein. A large proportion of adenosinetriphosphatase (and also catalase) survived the dehydration process. (See page 410)

Dehydrocanning *Apples*

Dehydrocanned apples. M. J. Powers, W. F. Talburt, R. Jackson, and M. E. Lazar.

A method has been developed for preparing canned, double-strength, apple pie stock. It involves dipping fresh slices in salt and citric acid, drying rapidly to about double strength, blanching to inactivate enzymes and to preheat for canning, filling tightly into cans, sealing hot, cooking, and cooling. Storage stability is good through one year at 70° F. but browning occurs on storage at 90° F. Chief advantages are economies in packaging, transportation, and storage. (See page 417)

Quality improvement *Tomato juice*

High viscosity of cell wall suspensions prepared from tomato juice. R. T. Whittenberger and G. C. Nutting.

Viscosity of tomato juice was doubled and even tripled by removing the soluble components from the juice. For example, viscosity was increased from 230 apparent centipoises (cp.) to 700 cp. by washing the juice on a fine sieve. The washed product resembled a puree in consistency, although its solids content was only 0.7%. Viscosity remained high following the addition of soluble non-ionic substances such as sugars, but was reduced greatly by the presence of electrolytes. Even the small amount of electrolyte occurring naturally in fresh tomatoes was sufficient to hold viscosity at a relatively low value. Microscopic observations and chemical tests showed that high viscosity was associated closely with the cell wall fraction of the juice. Pure cellulose walls at a concentration of only 0.2% gave a suspension as thick as the original whole juice containing 6.3% total solids. The commercial significance of these findings is discussed. (See page 420)

Packaging *Fresh poultry meat*

Effect of packaging materials and techniques on shelf life of fresh poultry meat. J. V. Spencer, F. E. Wells and W. J. Stadelman.

A study was made on the effect of various packaging materials and techniques on the shelf life of fresh poultry meat. Parts of this study involved meat treated with 30 p.p.m. of both chlortetracycline and oxytetracycline. A third part involved untreated meat. Cellophane sheets, polyvinylidine bags (Cry-O-Vac) and polyvinylidine sheets were used as the protective coverings. Data are presented to show the effect of the type covering and the influence of antibiotic treatment (with and without evacuation of air) on storage time. Determination of time to spoilage was determined organoleptically while slime smears were made to observe changes occurring in the microflora as storage time progressed. Differences in shelf life relative to packaging techniques were observed. Partial evacuation of the containers was found to account for increases in "shelf life," regardless of the treatment the meat received prior to packaging. (See page 425)

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

September 7–12	134th National Meeting of the American Chemical Society, Chicago, Illinois
September 21–28	Eleventh World's Poultry Congress, Mexico City, Mexico
October 13–15	Association of Official Agricultural Chemists, Inc., Shoreham Hotel, Washington, D. C.
October 22–24	Fifth National Vacuum Symposium, American Vacuum Society, Sir Francis Drake Hotel, San Francisco, California
December 26–31	American Association for the Advancement of Science, Washington, D. C.

1959	
May 17–21	Nineteenth Annual Meeting of the Institute of Food Technologists, Bellevue-Stratford Hotel, Philadelphia, Pennsylvania
1960	
May 15–19	Twentieth Annual Meeting of the Institute of Food Technologists, Civic Auditorium and Hotel Whitcomb, San Francisco, California
1961	
May 7–11	Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York
1962	
June 17–20	Twenty-second Annual Meeting of the Institute of Food Technologists, Americana Hotel, Bal Harbor, Miami Beach, Florida

An open invitation is extended to readers of FOOD TECHNOLOGY Illinois notices of annual or national meetings of interest to food technologists. to send in to the Editorial Office, 11406 South Bell Avenue, Chicago 43,

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Food Preservation by Radiation as of 1958

A Report to Management

Kevin G. Shea

Executive Secretary, Interdepartmental Committee on Radiation Preservation of Food, Washington, D. C.

THE ARMY'S radiation preservation of food effort represents a response to the challenge created by new weapons. The product of this new technology will, with improved dehydrated food products, provide added support to a feeding system that proposes no refrigeration for food in the combat zone. Implications of the process to American business and to consumers other than military have been recognized by industry as well as by various interested nondefense Government agencies.

Government interest has resulted in the formation of the Interdepartmental Committee on Radiation Preservation of Food (Figure 1). The Committee is composed of top-level representatives from the Departments of State, Army (representing the Department of Defense in this field), Interior, Agriculture, Commerce, the Department of Health, Education and Welfare, the Atomic Energy Commission, and Small Business Administration. On May 15, 1956, acting upon the suggestion of Secretary of Defense, representatives from six of these agencies met to form the Interdepartmental Committee. Shortly thereafter the Department of Interior joined this group and in January 1958 the Small Business Administration also became a member. Each agency, of course, had its special interests and appointed representatives to various of 21 subcommittees, whose joint activities blanketed the Government effort *(1)*. This interest on the part of industry and government has resulted in their active participation, which, in turn, argues well for development of firm industry capability—upon which rests the Military's best hope in times of crises. In recognition of this fact, and cognizant of the need for a careful appraisal, representatives of the subcommittees of the Interdepartmental Committee met on November 20, 1957, and reviewed the Government effort. Later, at Gatlinburg, Tennessee, January 1958, the Fifth Annual Contractors' Meeting was held by the U. S. Army Quartermaster Corps and several days of discussion and review took place with over 200 contractors' representatives from industry, universities and related fields and other interested people in attendance.

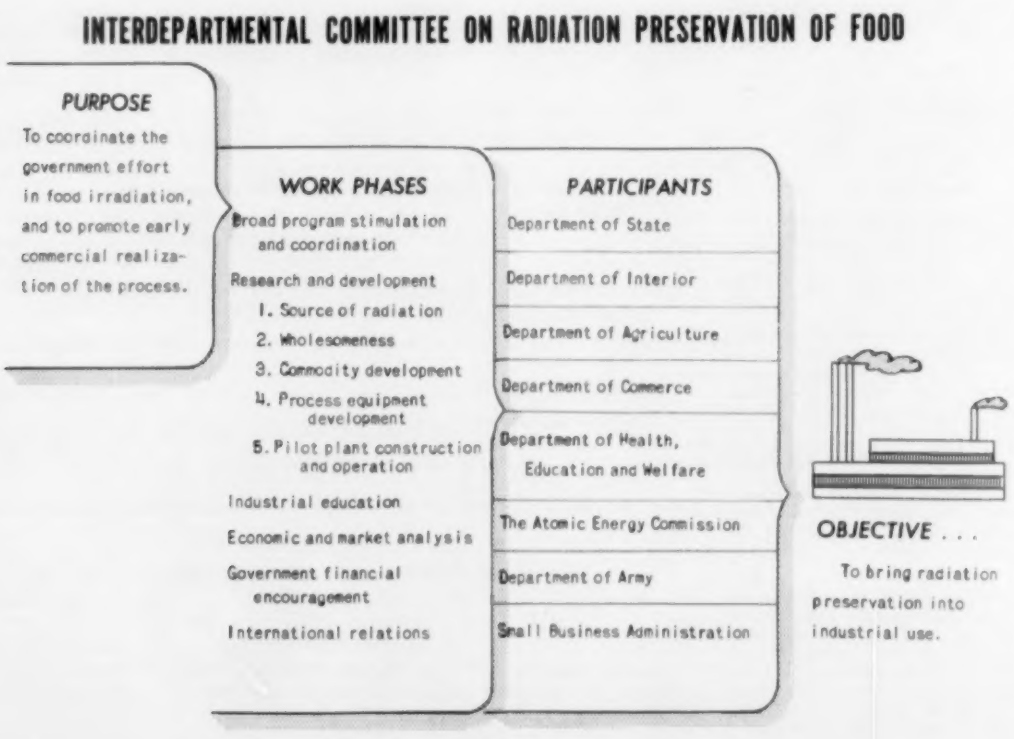

INTERDEPARTMENTAL COMMITTEE ON RADIATION PRESERVATION OF FOOD
PURPOSE
To coordinate the government effort in food irradiation, and to promote early commercial realization of the process.
WORK PHASES
Broad program stimulation and coordination
Research and development
1. Source of radiation
2. Wholesomeness
3. Commodity development
4. Process equipment development
5. Pilot plant construction and operation
Industrial education
Economic and market analysis
Government financial encouragement
International relations
PARTICIPANTS
Department of State
Department of Interior
Department of Agriculture
Department of Commerce
Department of Health, Education and Welfare
The Atomic Energy Commission
Department of Army
Small Business Administration
OBJECTIVE . . .
To bring radiation preservation into industrial use.

Figure 1.

Discussions ranged over the entire field, outlining major achievements and reviewing problems. The tone of the meetings was optimistic and reflected an increased mutual understanding of the magnitude of the task. Decisions were arrived at through open discussion, and confidence in the successful application of radiation to food preservation was much in evidence. Di cussions chiefly involved efforts to refine the process and to determine and increase product acceptability. Much of the following information is based upon that presented at these meetings.

PRESENT PRODUCT STATUS

Various foods have been successfully irradiated, using the diverse available sources, some at sterilization levels, some at lower doses. A list of foods of particular interest to the Armed Forces that have been subjected to intensive investigation follows:

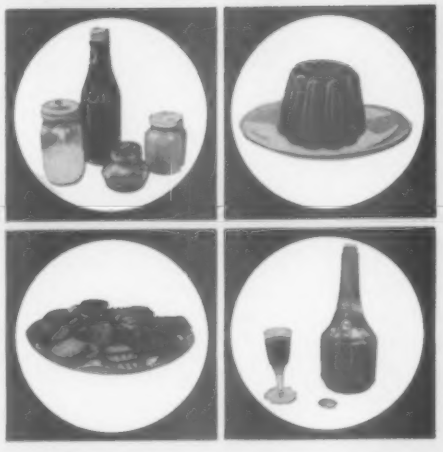
Pork	Carrots
Bacon	Cabbage (Slaw)
Chicken	Apples
Beef	Peaches
Lamb	Citrus (Lemons and Oranges)
Cod	Dried Fruit
Shrimp	Flour
Potatoes, White	Cereal Bar
Potatoes, Sweet	Beef Stew
Green Beans	Chicken Stew
Broccoli	

Many of these foods have been stored successfully at room temperatures; others are still under test. Extensive "wholesomeness" tests have been conducted for these or similar products. One, a pork product, has progressed to the point where a tentative purchase description is being drafted.

Meat

Sterilized irradiated precooked pork loin is a particularly attractive product and studies indicate that it is both appetizing and nutritious. After clearance for wholesomeness the Army will solicit a trial procurement of this product. Although the economics are not yet defined, other meats such as sterilized chicken and bacon also are indicated as likely candidates for clearance by the appropriate Government agency and for industrial support.

"Radio-pasteurization" of meats, smoked or otherwise, such as sliced sausage, retail beef and pork cuts and chicken parts, has attracted the interest of various meat packers. The extended shelf life resulting from this process opens the door to the development of new and advantageous marketing techniques. The time gained in the market channels will allow the meat packer sufficient time to prepare, package, label, and ship retail cuts of meat. Other commercial probabilities include a meat tenderization process, based on high holding temperatures and sanitary control through irradiation. The commercial value of marketing pork products, guaranteed to be trichina and disease free, which would cost only a cent or so more per pound than untreated pork, undoubtedly has intrigued the management of large meat packing companies.



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Seafood

Seafood has also been successfully irradiated. Radio-pasteurization presents an opportunity to the fisheries industry to reverse the declining trend of the "fresh" fish market. Crab meat, a high cost item in popular demand, has been successfully held at low temperature after low-dose irradiation, for several times its normal shelf life. Higher doses generally result in increasing off-flavor and odor and these characteristics vary quantitatively with the pretreatment and the species. The storage life of Pacific cod fillets has been extended over 4 times through low dose irradiation.

Fruits and Vegetables

It has been estimated that 25 to 50% of the fruits and vegetables scheduled to be eaten fresh spoil before being consumed. This unfortunate situation has created a strong economic incentive which makes it probable that radio-pasteurization of fresh produce will be one of the first industrial applications in the food field.

Profit possibilities in shipping radio-pasteurized fruits and vegetables (strawberries, peaches, grapes, lettuce, etc.) to off-season markets has seized the interest of various food preservation and transportation companies. Products irradiated thus and then refrigerated can be shipped to the New York market from areas as far distant as California. Studies at the University of Michigan, based upon experimental evidence and upon the loss claim records of various railroad systems *(6)*, anticipate large savings from the control of "brown rot" of peaches. Furthermore, the Michigan workers have found that the flavor of canned peaches can be improved through the use of radio-pasteurization to allow the harvesting and handling of mature peaches without undue loss prior to canning. Sprout inhibition, particularly of potatoes, enables this important staple to be held for longer periods at higher temperatures. The outlook is good for combination processes (high-temperature, rapid-heating, and irradiation) for sterilizing pureed sweet potatoes, squash, pumpkin and the like. Such diverse products as corn and peaches have been sterilized through the use of irradiation alone but, to a greater degree than is true of such older processes as canning, much remains to be done.

Industry Interest

Recent signs of independent industrial interest are at hand. Hotpoint Company workers report significant extension of refrigerator shelf life of foods with a "gamma tray" *(3)*. The gamma tray contains a very small amount of cobalt 60. The satisfactory storage life of fresh vegetables in the gamma pan is stated to be 1.4–1.7 times the untreated controls. Of interest also is a patent recently issued to the Nuclear Corporation of America, Inc. *(7)*, involving cargo carried in a reactor powered ship. The proposal is to irradiate the cargo en route to market, using the radiation source at hand. Such irradiation would control post harvest diseases of fruits and vegetables, delay germination of grain, and inhibit the sprouting of root crops.

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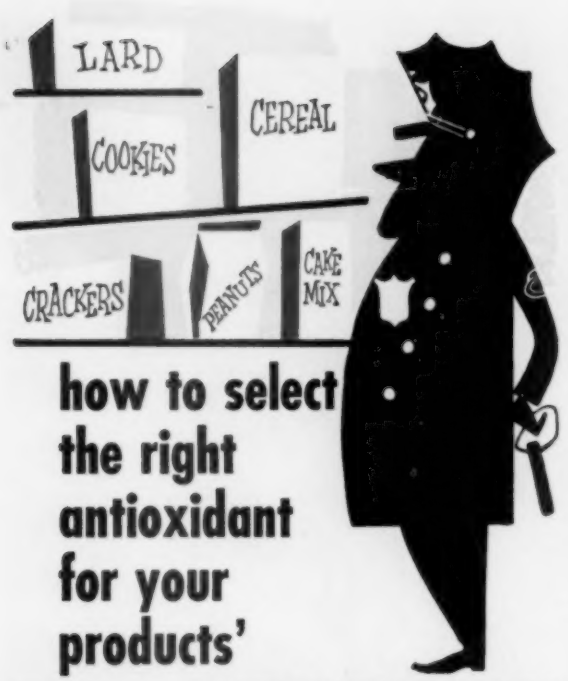

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Another evidence of industry interest is the appearance of want ads that seek personnel whose specific responsibilities will be to keep management informed of significant developments in food irradiation. Large banking houses, insurance companies, and financial management firms continually monitor the field.

AREAS OF CURRENT AND CONTINUING INTEREST

Required Dose

The following approximations of the required radiation dose have been established for 4 types of application:

Sprout inhibition	10,000 rads[a]
Insect deinfestation	50,000 rads
Pasteurization	500,000 rads
Sterilization	4,800,000 rads

It should be stressed that these values are tentative and their inclusion in such a list tends perhaps to lend a spurious finality to these values as against those as yet undetermined. There are strong indications, for example, that the sprout inhibition dose may be reduced 50% or more. The importance of such a reduction is illustrated by recent experience with potatoes irradiated at 20,000 to 40,000 rads. These potatoes show an increased incidence of rot in storage due to inhibited wound healing. Present indications are that reduction in dose rate will aid in overcoming this problem, as will the determination and selection of those potato varieties most resistant to radiation damage.

The sterilization dosage listed is based upon formulas derived from the canning industry's experience and assumes a highly contaminated raw product. It is generally accepted as a useful bench mark at this stage of the process. However, the validity of the transfer of such principles to a process of a different kind is being examined. The figure is necessarily oversimplified and will be subject to much future evaluation. The evidence indicates that the sterilizing dose required varies with the product irradiated and the initial bacterial load *(5)* and requirements frequently have been below 4.8 million rads. (Present information indicates a sterilizing dose between 3 and 6 million rads, depending on the food irradiated and the use of combination treatments.) Furthermore, the use of control measures of demonstrated validity, such as in-plant chlorination, can lower the contamination load and thus lower the required dose. This type of control has already been accomplished by industry in cooperation with the Armed Forces in the procurement of such products as the Frozen Precooked Meal *(2)*.

Sterilizing doses will not deactivate enzymes, however, and in time and at higher temperatures this will affect stored food quality. Since these naturally occurring substances are inactivated by pasteurizing or cooking temperatures, the combination of heat plus radiation to sterilize meat and other foods is particularly attractive. Various additives, for example, the antibiotics, offer much promise with respect to lowering dose requirements.

[a] Rad—A unit of radiation measurement: The absorption of 100 ergs of energy per gram of material.

Radio-pasteurizing dose requirements are being determined for specific microorganisms in order to establish the required dose more accurately. Industry is particularly interested in radio-pasteurization as the shelf life of foods, normally with some refrigeration, can thus be extended. At the same time, problems related to wholesomeness and acceptability are minimized. Similar studies with various insects will help bracket the "insect deinfestation" dose.

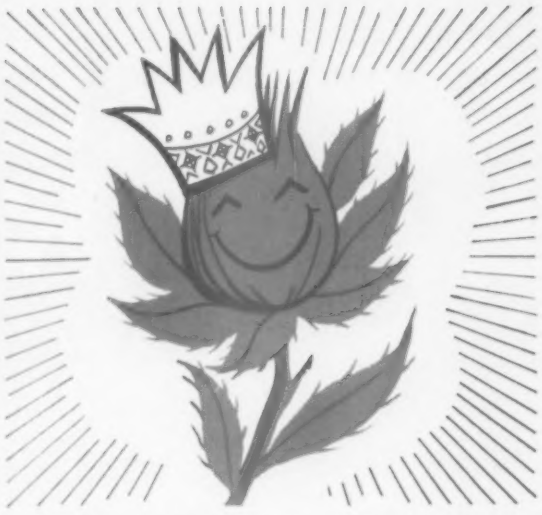
Acceptability

The problem of dose leads directly to that of acceptability since flavor and odor molecules are altered, frequently unpleasantly, as the dose increases. The immediate solution would be to lower the total dose required through the use of additives or combination processes or otherwise. Concurrently, foods of greater inherent resistance to irradiation damage should be determined and utilized, just as we now have a "canning" as well as an "eating" peach, a prune as well as a plum. Ultimately the results of fundamental research in this area, presently increasing in numbers of individuals engaged and scope, should provide solutions.

However, there is no foreordained reaction to a new flavor by an individual. Numerous new flavors have been received with favor in the past; an example frequently cited is pasteurized milk, now normally preferred to raw milk. Many specialty cheeses and other foods of exotic taste have achieved wide acceptance, and hence it may well be that some of the flavors induced by radiation will gain approval. Various canned foods are preferred by some individuals to their fresh or frozen counterparts—evidence that preservation in itself is not a deterrent to acceptance. There are many other examples of this fact.

The determination of acceptability is subjective. The Army has noted a wide variation in taste panel results reported by its contractors from time to time throughout the country on similar irradiated foods. It is generally recognized in the field of food technology that there is lack of standardization of both specific techniques and of interpreting results *(1)*. Heavily irradiated food has been rated highly by one laboratory and similar food treated to a lighter radiation dose has been rated poorly by another. The Army is presently standardizing the interpretation of the results of its contractors. Of course, other factors than the attitude of the taster may operate and are being investigated: poor dosimetry or lack of knowledge of the true dose that the particular food being tested has received may have been a factor in the past. Other possibilities include varying genetic characteristics of the "same" kind of food, or the effect of packaging material, and so on.

The problem of acceptability will be greater for the civilian trade than for the Military, as food preparation procedures, which may in some cases be the determining factor, can be controlled more closely by the latter. The Department of Defense recently announced a troop acceptability test, wherein irradiated food would for the first time be served as part of a regular meal in a mess hall. This test started at Fort Lee, Virginia, during the week of April 27, 1958, and will yield the first information of its kind.



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Dosimetry

The problem of acceptability is related to dose and equally to that of dose measurement. Within the past year it has become possible to measure dose with greater precision than heretofore. A degree of calibration has been achieved at the National Bureau of Standards on dose-measuring equipment of interest to the Army's effort in this field. Cheap dosimeters, accurate over the range envisioned, must be developed and used before and during processing, however, to definitely establish the absorbed dose. The absence of such guarantees would preclude the use of the process. Precise or reasonably precise control of dosage minimizes off-flavor production. Overdose could precipitate serious losses. Underdose, even more undesirable, would permit survival of destructive and even deadly microorganisms. While considerable strides have been made in dosimetry, more precise measurements and controls will be required for effective processing.

Until recently, dosimetry was concerned with medical therapy applications in which dose magnitudes and rates are very low compared to that contemplated in this new technology. The National Bureau of Standards has begun work on a graphite calorimeter and a graphite ionization chamber, either one of which could serve as the country's primary dosimetry standard and against which all other secondary standards could be calibrated. The radiation project at the Quartermaster Food and Container Institute for the Armed Forces has adopted a secondary standard dosimetric system which eventually can be calibrated against a national primary standard. This system is based on work done at the Stanford Research Institute and has been recommended by the National Research Council subcommittee assigned to food radiation. SRI is also developing a continuous monitoring system for the sources to be installed at the U. S. Army Ionizing Radiation Center planned for construction in Lathrop, California. This system undoubtedly will be closely observed by those Government agencies concerned with inspection and health hazards. Rapid advances in these fields will be critical to the acceptance and wide use of the process.

Wholesomeness

The Surgeon General of the Army is running an exhaustive series of tests using a protocol developed jointly with the Food and Drug Administration. To date there has been no evidence of toxic or other adverse effects from consumed irradiated foods. There have been some losses in vitamins, comparable to that experienced with canned food. There has been no significant difference in the metabolic availability or the digestibility of irradiated as opposed to identical but nonirradiated foods.

In order to obtain consumer preference evaluation, various foods, selected for class coverage and to give a variety which in sum will be adequate for a one-month non-monotonous diet composed entirely of irradiated foods, are scheduled for evaluation, as mentioned, at Fort Lee, Virigina. The foods are to be fed singly as part of a nonirradiated diet. Each troop volunteer, selected by the Surgeon General's

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representative for participation, will be examined before and 3 months after his participation in these tests.

Packaging

Recent research indicates that the loss of physical properties of irradiated packaging materials is small and of little significance. The change in chemical properties of the packaging materials is of great importance since minute amounts of substances produced through irradiation may result in undesirable side effects in food. Such substances must be avoided. It is also necessary to improve these containers and their closure so as to prevent bacterial recontamination.

At sterilizing doses the only satisfactory container at present is the commercial tin can. Although these cans are suitable for irradiation by cobalt 60, there is a theoretical possibility that the 24 MEV electron accelerator to be installed at Lathrop, California, may cause induced radio-activity in the can. As with canned foods, the choice of can enamels will vary with the product.

Economics

The long term economic and market impact of radiation preservation of food cannot yet be determined. In the last analysis, this will depend largely upon the ultimate costs of sterilization or pasteurization of various commodities by radiation as contrasted with comparative costs by alternative forms of food preservation in relation to additional benefits which may be obtained through this new method. The economic impact will also be contingent upon the rate of technical progress made in achieving minimum measures of wholesomeness for individual commodities and in securing consumer acceptability.

The U. S. Army Ionizing Radiation Center proposed for the Lathrop, California, site has, as one of its main functions, a determination of the economic parameters on a pilot plant basis. The troop feeding experiment at Fort Lee may contribute valuable information on acceptability.

The subcommittee on Economic and Market Analysis of the Interdepartmental Committee is currently collecting and analyzing data and plans to issue a series of reports dealing with economic considerations as soon as adequate information is available for this purpose.

PATENTS

An early patent application in the field of preservation of foodstuffs by the use of radioactive fission products was filed in the name of Dr. Lyle E. Borst, September 2, 1944, by the Government's Office of Scientific Research and Development. This application was assigned to and prosecuted by the Government, but never matured into a patent.[b]

[b] The complete patent application, Serial Number 552,558, has been accessible to the public since April 29, 1952, and either can be inspected on the premises of the U. S. Patent Office, or a photostatic copy of the application (or, if desired, of the complete application file) can be obtained from the Paten Office at a cost of 30c per typewritten sheet. A brief and rather incomplete abstract of the patent application appeared in the Patent Office Official Gazette of April 29, 1952.

The Borst application describes 3 alternate processes:

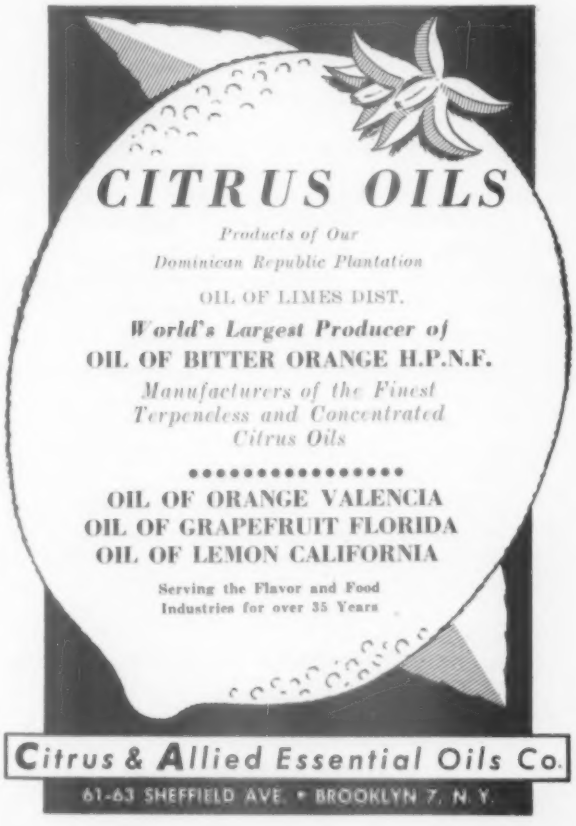
1. Treating food by conveying it into the close vicinity of Uranium 235, undergoing fission in a reactor;

2. Treating food by conveying it, by means of a conveyor mechanism (or conduits, in the case of liquid foodstuffs, such as milk) into the close vicinity of a concentrated source of radioactive fission products already formed; or

3. Incorporating radioactive fission products with the food before canning.

The statements of the Borst application thus are now publicly available. Patents and patent applications for the treatment of foods with high speed electrons such as those produced from a high voltage electron accelerator do not, it is understood, fall under the provisions of the Atomic Energy Act and are treated like any other patent or application.

A number of patents for processes of treating foods with high speed electrons have already been issued to various patent owners, and other patent applications are undoubtedly pending. Presumably, there may still be much room for new ideas in the field of treating foods with high speed electrons, e.g., in the development of conditions that will avoid off-flavors, improve the "penetrability" of food items, minimize the dose required and the like.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CONCLUSION

This new preservation method must develop naturally, fully supported by research. Unfortunately, many of those who are watching this novel process develop tend to think in terms of the older methodologies. But this new development cannot by its very nature be a duplication of previously existing technologies such as canning. Certain differences stand out. For example, irradiated foods require massive doses of radiation energy to inactivate enzymes, whereas enzymes are easily destroyed by heat. But heat, on the other hand, causes changes in the characteristics of foods that are different and of greater magnitude than those induced by irradiation.

Real strides have been made in progressing food irradiation toward its goal. The information being derived must be utilized intelligently, however, and with due regard for the problems entailed in fitting a new mode of preservation into the food industry and the food economy.

The economics of the process remain to be defined. It can be expected that effective plant inspection will make it possible to use a lower sterilizing dose for military procurement. Well-directed control of food preparation procedures should result in greater acceptability by the military consumer. Industry will tend to work, no doubt, with lower-than-sterilizing doses at first. But in view of the fact that fully acceptable, completely sterile products have already been produced in the laboratory, there is no reason to doubt that sterilization will ultimately be practicable.

The canning industry has not developed a method of preserving steak and the frozen food industry has not found a means of freezing lettuce. Nor is it to be anticipated that this newest of preservation forms will be applicable to all foods. Yet, from the evidence presented at two recent meetings, it certainly will have many applications.

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Of Professional Interest

Safety Evaluation Procedures and Interpretations*

Henry F. Smyth, Jr.

Mellon Institute, Pittsburgh, Pa.
and Union Carbide Corporation,
New York, N. Y.

THIS SPRING, under some old apple trees, I found what I took to be a fungus, growing rather abundantly. It resembled nothing I had ever seen before, nor any thing I would want to eat, but it seemed to my untrained eye to match a picture of the morel in an old National Geographic. The caption said it is an epicure's delight, safe to eat when in good condition. My wife recalled an essay by Louis Bromfield, describing the ecstatic thrill of finding 6 morels, and I had 24, if they really were morels. I harvested them and gave them to my secretary. She relied upon my identification, of which I myself was uncertain, and reported them to be delightful. A second crop of 12 I tried on a colleague, who likewise survived in a state of bliss. The consistent results of this limited human experiment on safety and consumer acceptance convinced me. My wife and I ate the third crop ourselves, regretting only that five-sixths of the total yield had been devoted to the evaluation of safety. An industrial firm which spent five-sixths of its potential profits on evaluation of safety would not long remain in business, but my resources can stand the strain for a luxury item like the morel. Furthermore, there may be a crop next year, and safety has now been established.

What I have to say about safety evaluation applies with equal force to intentional additives used to improve the character of food, and to incidental residues which may remain in food from the use of compounds in production, processing and packaging. The reason for material being present in food has no bearing on whether or not it is safe. The amount present has great bearing on safety.

It seems to me there is much loose talking and thinking on the subject of amounts. We shouldn't talk in quantitative units unless we have a tactual or operational concept of their magnitudes. How do you visualize one part per million? It is one drop (0.06 ml.) well mixed with 16 gallons, or 80 fifths. This makes a very dry martini indeed. If the perfect host had served a fifth of gin as these dry martinis every day of the Christian era, more than a quarter of his fifth of Vermouth would remain unused today. A tenth of a part per million is the thickness of a strip of cellophane in the height of the Washington monument. A part per billion is of the order of one drop in a tank car. We talk in terms of these quantities of incidental residues in foods, we must seriously question the effects upon health of their presence, and we must devise analytical methods to measure them.

Increasingly recognition is being accorded to the fact that every action of an additive grows less as the intake falls. At some low intake of any additive, no informed person could attach public health significance to applications. There is no sound reason to regulate applications which produce extremely low intakes. They are inconsequential, insignificant or ignorable. Visualization of the tactual definitions which I just gave for certain low levels should be convincing on this point. Who can develop concern for one drop of any probable residue in a tank car; or of several drops? At what level does concern become justifiable? This has not yet been clarified, and it will probably be different for every class of additives.

The Food Protection Committee *(3)* defines safety as "the practical certainty that injury will not result from use of a substance in a proposed quantity and manner." There are two very important points in this definition. Conclusion that the use of an additive is safe does not require absolute certainty that no injury can result, it requires only a practical certainty. Some undefined degree of uncertainty is compatible with the conclusion that safety has been shown. Furthermore, it is a particular use of an additive in a particular food at a particular level which is shown to be safe, it is not the additive itself which is safe under every foreseeable condition of use.

CURRENTLY USED TECHNIQUE

Due to precedent and administrative practices the evaluation of safety of applications of chemicals to food technology in the United States, and increasingly in the rest of the world, now usually rests on a rather standardized experimental regimen *(5)*, which has developed out of the 1942 work of Morris, Nelson and Calvery *(6)*. I see no point in dwelling upon the details of this well-known program. In outline, several concentrations of the additive are fed in the diet to groups of rats for 2 years. One of them must produce no discernible difference from rats receiving none. One of them, or a higher concentration fed for

* Presented May 28, 1958, in a panel session on "Important Current Aspects of Food Additives," Moderator, Dr. Frank L. Gunderson, Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago.

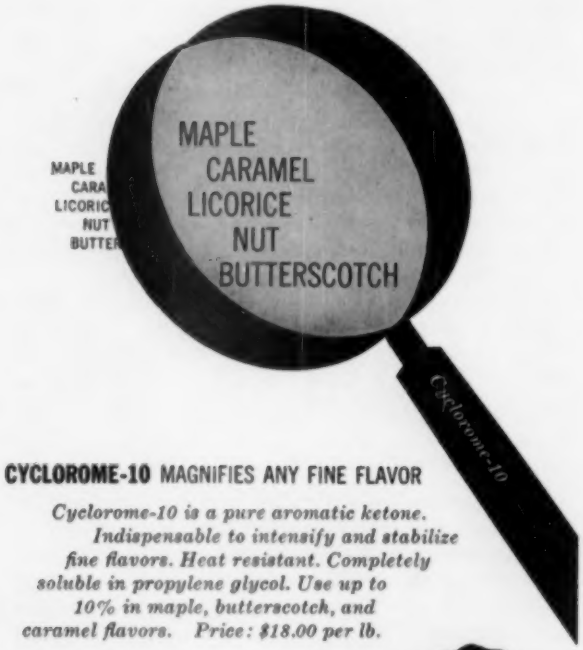
a shorter time, should produce an effect sufficient to allow determination of the nature of injury from an excess. Smaller groups of dogs, or some other non-rodent, are fed more than one concentration for one year. One of these concentrations must result in no discernible difference from dogs receiving none. From these studies there is deduced a "no-effect" level of the additive for the more sensitive of the two species. It is desirable to determine the metabolic path followed in each of the two species and in humans. If the path in only one of the species is like that of the human, then the "no-effect" level in the human is likely to be closer to the "no-effect" level in that species, rather than to the more sensitive of the two species.

There is another way in which uses of a very limited number of additives have been shown to be safe. It may be loosely termed the metabolic approach. The additive may pass through the digestive tract unabsorbed and be completely recoverable from the feces. It may be transformed by digestive enzymes or bacteria in the digestive tract into a compound known to be harmless. It may be a material which is normally present in some foods, and its use as an additive may not materially increase the total consumption. It may be metabolically closely similar to some usual component of the diet. When any of these facts can be shown to be true, use of the additive is *a priori* safe. They are not true of very many useful additives. Happily, proof of any one of these facts is possible in a positive sense, leaving no room for doubts about the adequate sensitivity of experimental methods.

There are a number of ways in which use of a particular additive may be shown to be unsafe. At a level reasonably close to that of its proposed use, the additive may exert a marked hormone-like physiological effect, it may inhibit some enzyme system which is important in metabolism, it may be stored in the body, or it may cause a specific irreversible pathological change. These actions also are demonstrable in a positive sense. When they exist, there is little room for argument. The proposed use of the additive is unsafe, although one may be misled by an experimental artifact, such as the chance reaction of one or two of a large group of animals, or an unrecognized special sensitivity of the species used for study.

SAFETY FACTOR

Having obtained agreement that we have defined the "no-effect" level of an additive fed to experimental animals, we proceed to predict the "safe level" of the additive for the human diet. We divide by a safety factor which combines our ignorance with our lack of confidence in the accuracy of the "no-effect" level we have so laboriously defined during a 3-year period.



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New Products and New Exhibitors at 1958 IFT Annual Meeting

Figure 1. Charles Greenfield, Fred S. Carver, Inc., Summit, N. J., Booth 78, who developed the Carver-Greenfield low temperature process for fat rendering explains details to R. W. Schumann of R. A. Johnston Co.

Figure 2. John D. Finch of The Quaker Oats Company, Industrial Sales Division, 345 Merchandise Mart Plaza, Chicago 54, Illinois, and Dan Ridenour of Wm. J. Stange Co., examine their Industrial Milling brochure. Mr. Finch is expaining the information needed by them to help solve cereal problems for prospective customers.

Figure 3. Henry W. Beck of Air Reduction Company, Inc., Booth 83–84 expains to Martti Knuultila of Illinois Institute of Technology varied applications of carbon dioxide in meat packing.

Figure 4. C. E. McLaughlin of Atlas Powder Company, Wilmington 99, Delaware, as seen at the IFT Annual Meeting Convention Booth 69 with Charles J. Michel of The Quartermaster Corps explains features of Atlas Powder Company's new mono- and diglyceride emulsion "Atmos 300".

Figure 5. The new salt dissolving tank on display by Diamond Crystal Salt Company, St. Clair, Michigan, is explained by C. W. Schornstheimer to Jack Akerboon of Best Foods, Inc.

Figure 6. Leslie F. Rutledge of Stokely-Van Camp, Inc., watches demonstration by R. C. Christiansen, Hoffmann-La Roche, Inc., Nutley 10, N. J., at booth 95 of new type of soluble carotene.

Figure 7. Seen at booth 93 is C. E. Lichtenauer of Algin Corporation of America, 24 State Street, New York 4, N. Y., talking to Wayne E. Maynard of Fleischmann Laboratories.

Figure 8. Kraft Foods Industrial Division featured Kraystay (extractive of Irish Moss) and Krafen (casein-free, fat-free milk serum) at the Eighteenth Annual Meeting of the Institute of Food Technologists. Kraystay is a vegetable stabilizing, suspending and emulsifying agent used in many foods to insure consumer acceptance, while Krafen is a spray dried cheese whey that provides beneficial properties in baking, ice cream, confectionery and other food industries.

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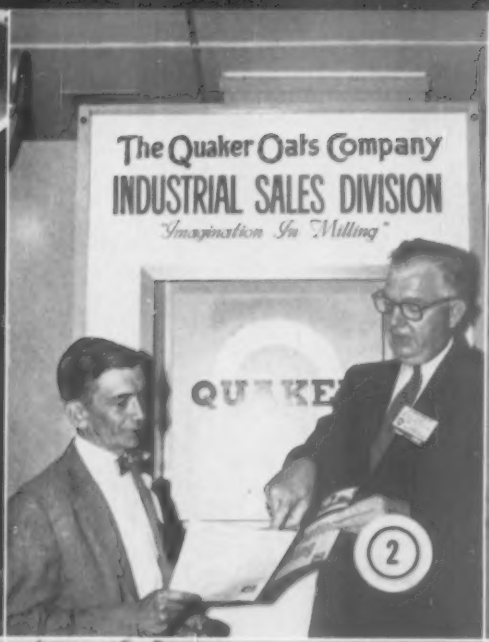
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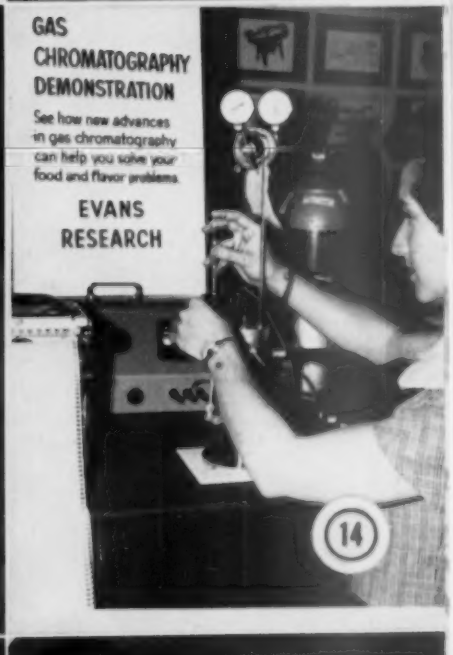
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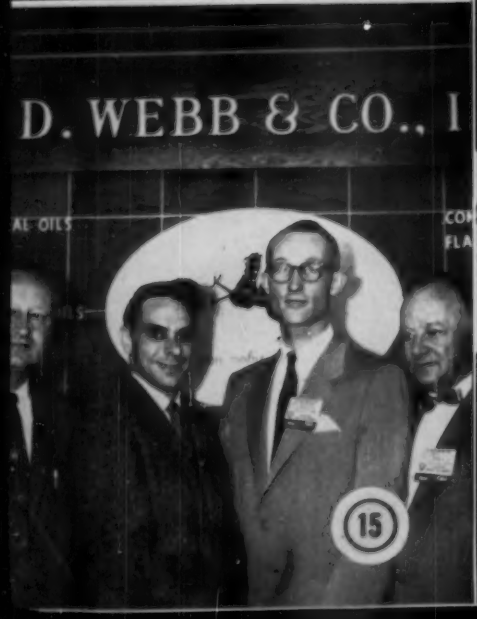
RESEARCH
14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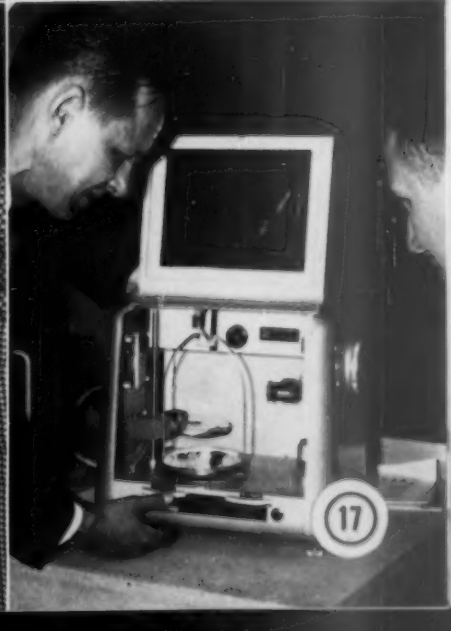
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There are several components of the safety factor. We concede that humans may be ten times as sensitive as our experimental animals *(2)*. We grant that the most sensitive human may be ten times as sensitive as the average human *(2)*. We increase the safety factor by an undefined amount when an excess of the additive may cause an alarming type of injury, when it will be in a universally eaten major item of the diet, or in an item eaten by a presumed particularly sensitive segment of the population. Furthermore, we reduce the safety factor by an undefined amount when favorable human experience has reduced the uncertainty about species differences, or when the necessity to use the additive is great.

These components of the safety factor are not added together, they are multiplied. Sometimes we end by concluding that there is a practical certainty that humans will not be injured by a thousandth or less of the intake which produced no detected harm in our experimental animals.

After estimating in this conservative fashion the "safe level" of the additive in the human diet, we examine the proposed uses. The amount of the same or similarly acting materials which human beings may receive in other ways is added to the amount which may be received from the proposed use. If the sum is less than the estimated "safe level," we conclude that the use is safe. Even this does not necessarily make it legal. The purpose of the additive, and the necessity for its use must be considered to establish legality.

It seems to me beyond question that our current procedures adequately protect public health from excessive consumption of additives in the diet. On the other hand, it seems to me that these procedures may unnecessarily hamper the efforts of food technology to produce and distribute an increasingly attractive, varied, and sanitary diet. Possibly the study of additives accepted as safe since the dawn of history could determine whether the current standards for safety evaluation are necessary, or are timidly over-conservative.

SHORTCOMINGS

The customary program for safety evaluation has the advantage of being well-defined. One has no doubts about the experimental work which is required. No great ingenuity nor any profound knowledge of physiology or of pharmacology is called for, although constant meticulous attention to detail is required to obtain dependable results. The work may serve its administrative purpose without revealing the true way in which an excess of the additive can injure. Although sound planning allows the one-year dog feeding to be completed simultaneously with the two-year rat study, almost another year is required to complete the study of micropathology and the analysis of the findings. Three years is a long time to withhold technical application of a promising additive.

The greater number of additives can neither be shown safe by the metabolic approach, nor clearly unsafe because of the positive evidences of serious effects which I have mentioned. One is usually compelled to rely upon the conventional chronic feeding study. Barnes and Denz *(1)* have discussed this study at some length.

The 2-year feeding period approximates the natural life span of the rat. Reliance upon its results has caused no injury to public health, but I believe only because an inordinately large factor is applied to estimate the intake safe for humans. It is a specious argument that feeding for the life of the rat is equivalent to feeding for the life of man. Wide acceptance today demonstrates that belief in magic symbolism is not dead. It is true that the rat receives the additive throughout every stage of its physiological development, maturity and senescence after weaning, just as the human will if the additive is put into use. However, the rat passes through these stages 35 times as rapidly as does the human. What esoteric mechanism causes the rat to be injured 35 times as rapidly as the human would be? If the life-time of one species is equivalent to that of another, why be hampered by the 2-year period required with rats? Why not rely upon the daphnia with its life span of a few days, its diet and metabolism not unlike man's *(8)*?

New Products and New Exhibitors at 1958 IFT Annual Meeting

Figure 9. G. O. Sampson of American Can Company, 100 Park Avenue, New York 17, N. Y., explains features of new pressure can to M. L. Kuboviak of Gulf Southern Corporation.

Figure 10. The latest in Recording Viscosimeters—C. W. Brabender Instruments, Inc., 50 East Wesley Street, South Hackensack, N. J. Walter T. Blake explains operation of their Viscograph, Type AV-1 to William E. Wimble and William Knightly of Atlas Powder Company.

Figure 11. Arthur Hartkopf of Brabender Corporation, 244 Saddle River Road, Rochelle Park, N. J. and K. H. Lorenz of F. Ritter and Company discuss moisture testing.

Figure 12. Dr. A. L. Elder of Corn Products Refining Company, 1001 Connecticut Avenue, Washington 6, D. C., discusses developments of corn products with Hugh Burgess of John C. Stalfort & Sons, Inc.

Figure 13. Seaplant Corporation, New Bedford, Mass., exhibited a new water gelling agent, SeaKem Type 410 at Eighteenth Annual Meeting. Mel Mickevic and Rex C. Stribley are seen at Seaplant Corporation's booth.

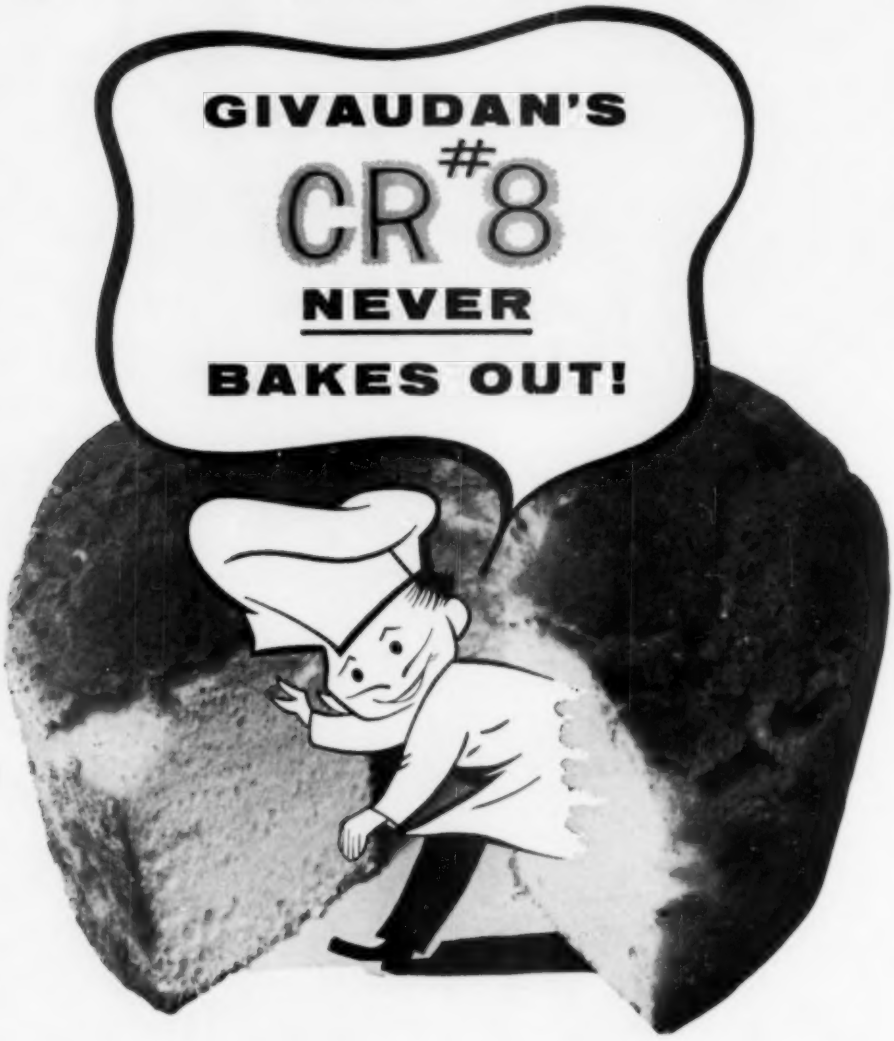
Figure 14. Miss Elinor Cohen demonstrates the operation of a new gas chromatography unit for flavor separation and identification for Evans Research and Development Corporation, 250 East 43rd Street, New York 17, N. Y.

Figure 15. Members of the firm R. D. Webb & Company, Inc., 137 Boston Post Road, Cos Cob, Conn., in attendance at the Annual Meeting are as shown Albert Daniels, W. Brindise, John W. Braitmayer and B. Jarvis.

Figure 16. New horizons in product development was the theme of the booth of Arthur D. Little, Inc., at the 18th Annual IFT Convention. Miss Pamela Low of the ADL Flavor Laboratory sniffs from a perfumer's blotter strip one of the five fragrances featured in a consumer preference game.

Figure 17. Jack Widick of Scientific Products demonstrates the new IR Moisture-Matic Balance to Earl J. Merwin of Givaudan Flavors.

A complementary additive to vanilla flavors...



Baked products faithfully retain their vanilla odor, taste and flavor strength when Givaudan's C. R. #8 is used as a fixative. Its resistance to high as well as low temperatures has been *proved in actual use* by the baking, candy and ice-cream industries. C. R. #8 is soluble in alcohol and propylene glycol. C. R. #12—a variation of C. R. #8—is also soluble in vegetable oil. Both are coumarin-free.

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Changes in the Total Volatile Base, Volatile Reducing Substances and Bacterial Count as Indices of Fresh Water Fish Spoilage

(Manuscript received February 20, 1958)

M. N. Moorjani, J. R. Iyengar, K. Visweswariah, D. S. Bhatia, and V. Subrahmanyan

Central Food Technological Research Institute, Mysore

SPOILAGE STUDIES on fish have been the subject of many investigations *(7)*. Numerous physico-chemical analytical procedures have been suggested for measuring the quality of fish but few have been found to be of sufficient general applicability to gain wide acceptance. Different indices of total volatile base (TVB) have been used to differentiate the various quality grades of fish. Widely varying TVB values *(1, 2, 6, 8, 10)* in the range of 13–30 mg. % have been suggested as the upper limit for good fish. Claims have been made for a test *(5)* of general applicability based on total volatile reducing substances for judging the freshness of fish. This method does not depend upon the presence of any specific compound but reflects the presence of a wide variety of volatile oxidisable or reducing substances liberated during bacterial decomposition of fish.

The present investigation was undertaken to assess the quality gradings of fresh-water fish by determining the changes in the volatile reducing substances and the total volatile base content. In conjunction with these two standard methods, the viable bacterial count has also been taken into consideration. Trimethylamine nitrogen estimations were not carried out because it was found that the total volatile bases of these fish were largely made up of volatile bases other than triamine.

MATERIALS AND METHODS

Common local varieties of fresh-water fish, i.e. "Gende" *(Barbus Carnaticus)*, "*Kooralu*" *(Barbus Dubious)*, "Arja" *(Cirrhina Fulungee)*, "Bale" *(Wallago Attu)* and "Machallu" *(Labeo* Spp.*)* were used in these investigations. The freshly caught fish were iced shortly after catching. Fillets were cut from the sides of these fish stored over-night in ice. They were sealed in moisture-proof cellophane bags and stored at 4° C. and 30° C. Samples were taken at regular intervals for analysis. The test samples were prepared by pressing a suitable amount of minced fillet in a Carver press; the press juice was centrifuged to obtain a clear aqueous portion. Volatile reducing substances were determined according to the method of Farber *(5)*; total volatile bases were determined by the micro-diffusion technique of Conway *(4)*. For viable bacterial counts, a 5 g. portion of fillet was cut under aseptic conditions and blended with 45 ml. of sterile water in a tissue homogenizer. After suitable dilutions, the bacterial load was determined by agar-plating, using a nutrient agar consisting of beef extract 0.3%, peptone 0.5% and agar 1.5% (pH 7.0). The plates were incubated at 23–25° C. for a period of 3 days and colonies were counted in the range of 30–300.

RESULTS AND DISCUSSION

In a series of carefully controlled experiments, the progress of spoilage was studied at intervals until the fish became totally unfit for human consumption. The rise in bacterial numbers in comparison with the rise in TVB and VRS of Gende *(Barbus Carnaticus)* stored at two different temperatures is shown in Figures 1 and 2. Since almost similar results were

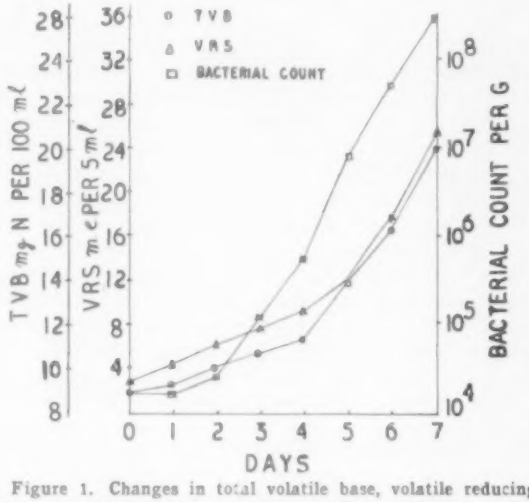

Figure 1. Changes in total volatile base, volatile reducing substances and viable bacterial count of Barbus Carnaticus fish fillets stored at 4° C.

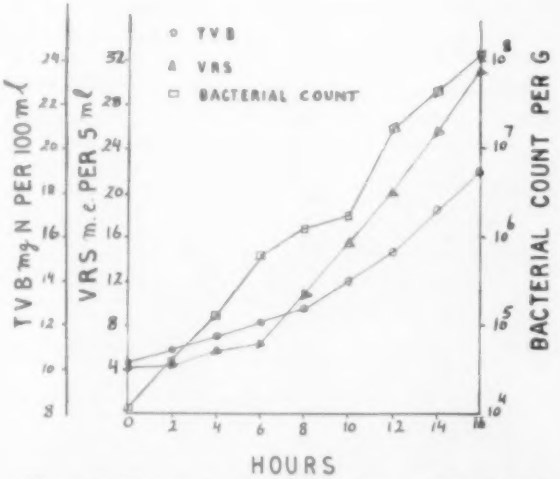

Figure 2. Changes in total volatile base, volatile reducing substances and viable bacterial count of Barbus Carnaticus fish fillets stored at 30° C.

TABLE 1

Changes in total volatile base, volatile reducing substances, viable bacterial count and organoleptic evaluation of Barbus Carnaticus fish fillets stored at 4° C.

Days of storage	TVB mgs. per 100 ml. juice	VRS micro-equivalents per 5 ml. juice	Bacterial load per g. of flesh	Organoleptic evaluation
0	8.8	2.6	0.02×10^6	Acceptable
1	9.3	4.4	0.02×10^6	Acceptable
2	10.0	6.2	0.04×10^6	Acceptable
3	10.6	7.6	0.1×10^6	Acceptable
4	11.3	9.2	0.75×10^6	Acceptable
5	13.9	12.0	9.25×10^6	Slight off odor, border line acceptability
6	16.3	17.6	75×10^6	Definite off odor, unacceptable
7	20.0	25.6	.....	Putrid odor; inedible

obtained with the other species of fish already mentioned, only the typical curves obtained with *Barbus Carnaticus* are presented here.

The TVB values remained relatively constant during the prime quality, increased to some extent during the second quality phase, and increased significantly during spoilage. During the first two phases, the increase in TVB considerably lagged behind a similar increase in the bacterial count. The increase in TVB between the initial value and the first appearance of odor was approximately 5 mg. The off-odors were definitely perceptible after an increase of about 10 mg. TVB per 100 ml. juice. These values can be used as an index of fish spoilage provided initial value of the fish in the question is known. The initial TVB values of these fish was about 9–10 mg. %. In some species of fish called double-breathers *(9)* the range in the variation of the original values was as great as the increase until the first appearance of off odors. These studies show that the maximum increase permissible for fresh-water fish of the species investigated is about 10 mg. % volatile basic nitrogen.

The volatile reducing substances (VRS) expressed as microequivalents reduction per 5 ml. juice increased coincident with the onset of spoilage indicated by organoleptic tests and by bacterial counts. The values increased more rapidly with progressive storage. Fish fillets were reasonably fresh up to a value of 8–10 for VRS, while slight off-odors were detected for VRS values below 15. A value of greater than 20 indicated definite off-odors.

TABLE 2

Changes in total volatile base, volatile reducing substances, viable bacterial count and organoleptic evaluation of Barbus Carnaticus fish fillets stored at 30° C.

Hours of storage	TVB mgs. per 100 ml. juice	VRS micro-equivalents per 5 ml. juice	Bacterial load per g. of flesh	Organoleptic evaluation
0	10.3	4.2	0.005×10^6	Acceptable
2	10.9	4.4	0.06×10^6	Acceptable
4	11.5	4.8	0.1×10^6	Acceptable
6	12.1	6.2	0.8×10^6	Acceptable
8	12.8	10.8	1×10^6	Acceptable
10	14.0	15.4	2.5×10^6	Slight off odor, border line acceptability
12	15.3	20.0	25×10^6	Off odor, doubtful acceptability
14	17.3	25.6	67.5×10^6	Pronounced off odor, unacceptable
16	19.0	31.0	.....	Putrid odor; inedible

The increase in bacterial count was associated with progressive spoilage of fish fillets stored at two different temperatures. Figures 1 and 2 show that when the bacterial counts reached approximately $\times 10^6$ per g. of tissue, the TVB and VRS values showed a very wide variation. However, it is difficult to make an accurate estimate of quality from bacterial counts. Castell *et al. (3)* have shown that species of the *Pseudomonas, Achromobacter, Serratia* and *Proteus* —like gram-negative rods produce offensive odors and spoil the fish more quickly; other species of bacteria, even though present in large number produce no apparent spoilage.

Considering the progressive increase in VRS and TVB, these values as indicated in the text can be tentatively proposed for various quality grades of fresh-water fish. It seems probable that the results in a modified form may be applicable to the other varieties of fresh-water fish.

SUMMARY

Fillets of fresh-water fish representing various species, stored at 4° C. and 30° C. for various periods under identical conditions have been examined to ascertain the inter-relationship among the changes during storage in total volatile base (TVB), volatile reducing substances (VRS) and viable bacterial count.

At the time, definite spoilage set in, the rise in TVB over the initial value was much lower than the corresponding rise in VRS. VRS value greater than 20 is indicative of definite spoilage. Organoleptic evaluation, VRS and bacterial count are interrelated.

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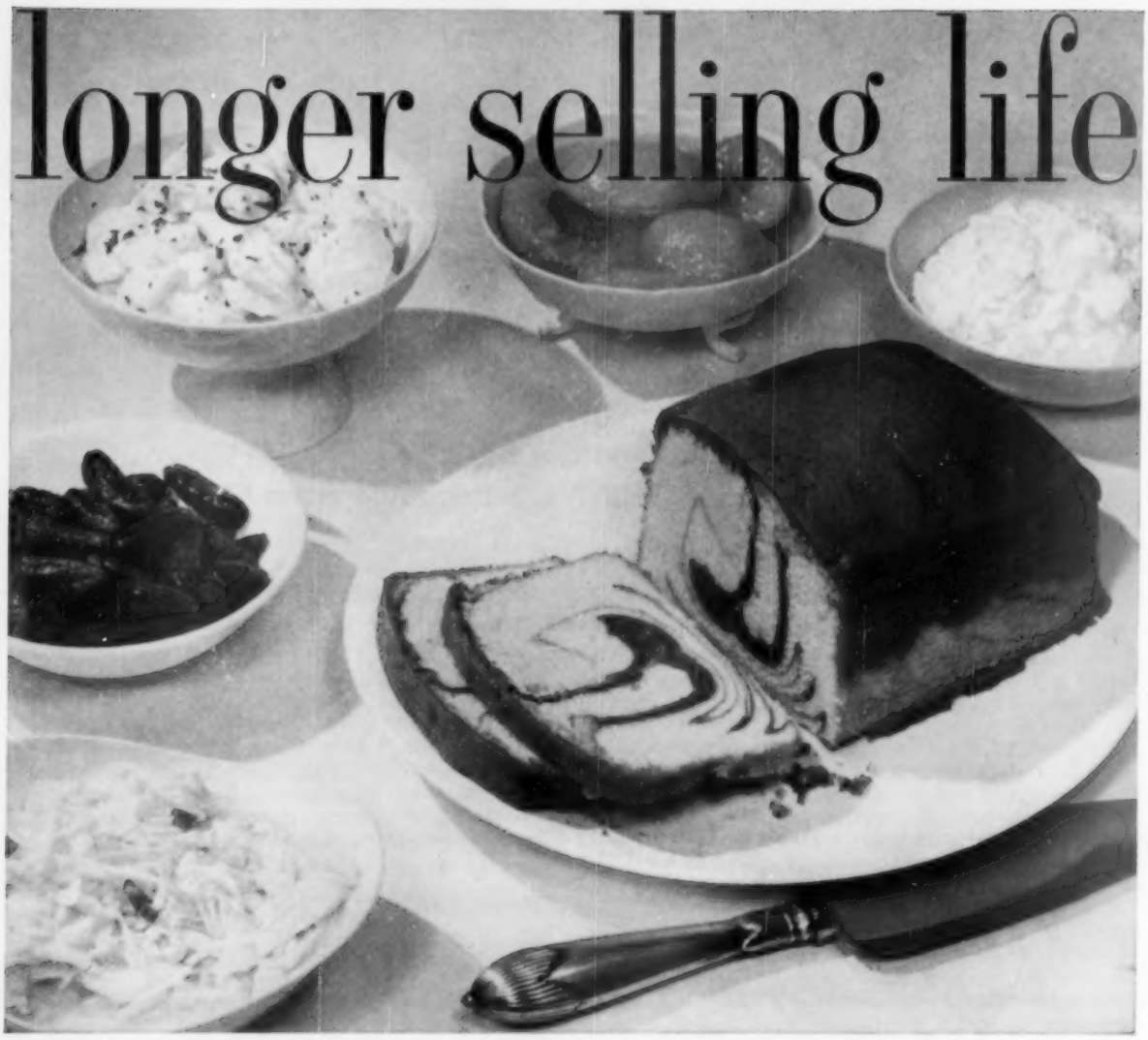

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386B

A Sampling Method for Household Surveys

I. Panel Recruitment for Testing Wines

F. Filipello
Department of Food Technology
and
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University of Viticulture and Enology,
University of California,
Davis, California

(Manuscript received February 24, 1958)

THE FOOD INDUSTRIES are well aware of the importance of determining consumer reactions to new and changed items and of following changes in food habits. Such studies are frequently made by the use of household surveys; yet there are great uncertainties when this procedure is used. One is sampling. Sampling is used in order to avoid the time and cost required in studying an entire population, the aim being to select a segment of the population, representative of the whole. The four basic steps in sampling are: (a) ascertaining the given conditions (what information and what degree of accuracy is desired); (b) selection of the sample design, size of sample and method of obtaining data; (c) procedures for collecting data; and (d) analysis of data.

Vital to success is the control of both sampling and non-sampling errors. Sampling errors arise from the fact that only a portion of the population is selected for study. Sound statistical practice requires that the sample be a probability unit; i.e., the sampling errors will be random and will tend to average out as the sample size is increased. Non-sampling errors can result from mistakes by the interviewers or by the respondents in reporting, computational errors, and by non-response. These errors, except non-response, can be kept within acceptable bounds by good control. If non-response is high, it is necessary to ascertain the extent to which it affects inferences obtained for the population.

From the theoretical viewpoint, probability sampling and the application of techniques have been widely discussed *(1, 2, 3, 4, 5)*. However, details of actual experimental usage are not readily found.

It is hoped that the study described in this paper will be of assistance to other investigators confronted with the problem of drawing a representative sample and recruiting a panel therefrom.

The problem of recruiting. Generally, the whole family (adults and minors) is eligible for a panel for testing attitudes toward non-alcoholic food items. Also, the test food is one that is either generally used or familiar to all. These factors tend to yield a high response and a high degree of participation.

Wine, however, offers a unique sampling problem. Minors, by law, are not allowed to purchase wine. Highly different attitudes with regard to wine consumption may exist not only between families but within a single family. Some religions forbid its use; others use it in their religious services. Wine consumption is not widespread, since approximately 15% of the United States population is responsible for 85% of the total consumption. These situations pose some difficult problems in formulating a procedure for panel recruitment for wine studies. Because of this the system employed was one which could be used for repeated approaches at a nominal cost.

SAMPLING PROCEDURE

The study was conducted in two cities: Woodland, California, a city of approximately 4000 families (January, 1957) situated in the center of a rural area; and Sacramento, California, a metropolitan area of 114,500 families (January, 1957) and highly industrialized.

Requirements for panel membership. The panel for both cities was to consist of a probability sample of families having a yearly income between $3,000 and $10,000. This limitation obtained a sample of the highest possible market potential; those under $3,000 yearly earned an insufficient income, while those over $10,000 contained a high proportion of families who made regular usage of wine.

A probability sample was defined as a random selection of dwelling units as listed in the latest city directory, and as amended by a check with post office listings. The dwelling unit was described as a group of rooms or a single room occupied or intended for occupancy as separate living quarters by a family or other group of persons living together or by a person living alone. The household was simply the person or persons who lived in one dwelling unit.

A second restriction on panel membership was the requirement that regular users of wine could not comprise over 25% of the panel. The purpose was to obtain more information from less frequent users and from non-users of wine. As the number of regular users offering to serve exceeded that required, the panel members in this classification were randomly selected from those willing to participate.

Recruitment procedure. In the Woodland study, which preceded the Sacramento survey, a pre-test of response was conducted to obtain an estimate of the extent and nature of the non-response. Three mailings were made to 100 families selected by a simple, random sampling from the city directory. The first two mailings consisted of a letter on a University of California letterhead, a recruiting card (Figure 1) and a stamped, self-addressed envelope. The letter in the first mailing explained the purpose of the study and made an appeal for cooperation. The second mailing, to those not answering the first appeal, contained a letter designed to encourage response from those who delayed and those who were undecided. Non-respondents to the second mailing received a third letter asking for reasons why they did not wish to participate. Those not answering the third letter were contacted by telephone or by personal interview. On the basis of the number of responses in this pre-test and the information obtained from the recruiting cards, it was determined that two mailings of a certain size would yield a panel of the required size and characteristics.

Sampling methods. In Woodland a simple, random sample was taken, as no information was available upon which to base a stratification. In Sacramento a proportionate, stratified sample was taken of the 17 homogeneous socioeconomic areas. The area division was made on the basis of similar census tracts.

Kindly fill in the information below and mail in the enclosed postage paid envelope by Tuesday, January 15th.

CONSUMER TASTE SURVEY

Date_____

Name_____

Address_____ Phone No._____

Number of Adults in Family_____

Best time of day to make delivery_____

How often is wine consumed? (check one)

1.____ Use once a week to several times a week

2.____ Use once a month to 3 times a month

3.____ Use 1 to 5 times a year

4.____ Never

What is your approximate yearly income? (Check one)

Under $2,000 ____

$2,000 to $3,000 ____

$3,000 to $10,000 ____

Over $10,000 ____

Figure 1. Recruiting return form.

RESULTS AND DISCUSSION

The pretest. The responses to the various mailings and final follow-up for the 100 family pre-test in Woodland are given in Table 1. It is seen that the first two mailings were sufficient to extract essentially all those qualified for the panel, as only one additional panel member was obtained by the third mailing. Beyond the second mailing, the general response is from those families not interested in participation, and a few who are not able to serve on the panel. The total response to two mailings was 79, with 33 of the families qualified for panel membership.

Woodland panel recruiting. A panel size of 200 was established for Woodland. On the basis of the pre-test, it was estimated that a double mailing to an additional 500–600 families, randomly selected, would be necessary to obtain a sufficient number to complete the panel of 200 families of desired qualifications.

Since 100 families had been used in the pre-test, there remained 3900 from which to draw the main body sample. A sampling rate of 1 in 7 was used; i.e., a household drawn at random from the first 7 (exclusive of business addresses) appearing on the directory lists and the 7th family thereafter. This yielded 557 households from which 500 were randomly selected for mailing, the remaining 57 being held in reserve in case more were needed to complete the panel.

TABLE 1

Response to Woodland pre-test mailing

	First mailing	Second mailing	Third mailing	Follow up[1]
Number of families	100	53	21	13
Total response	47	32	8	13
Qualified for panel[2]	16	17	1	0
Rejects	31	15	7	13
Summary of rejects				
Moved	6	3		0
Deceased	1	0	1	0
Income under $3,000	9	9	0	0
Income over $10,000	9	0	0	0
Late (out of town)	2	0	1	1
Not interested in survey	4	3	3	11
Sick	0	2	1	0
Unable to locate	0	0	0	1

[1] The non-respondents to the third mailing were reached by telephone and personal interview.

[2] Those having $3,000-$10,000 yearly family income and willing to participate, regardless of category of wine usage.

TABLE 2

Response to Woodland main body mailing

	First mailing	Second mailing	Total	Percent of total
Number of families	500	282	500	
Total response	218	146	364	73.
Qualified for panel[1]	136	71	207	41.
Rejects	82	75	157	32.

[1] Those having $3,000-$10,000 yearly family income and willing to participate, regardless of category of wine usage.

The response to the main body mailings is tabulated in Table 2. The total response of 73% compared favorably with the 79% obtained in the pre-test. The 41% qualified for the panel was somewhat higher than the 33% in the pre-test; however, this difference was not considered statistically important.

The two mailings to the pre-test and main body gave a total of 240 families qualified for the panel. Rejection of a portion of the regular users of wine in order to conform to the 25% requirement and subsequent rejections by the interviewers at the interview level left a final panel of 202 families.

Comparison of mail response for the two cities. In order to obtain information concerning minority groups the necessary panel size for Sacramento was determined to be 600 families having the previously mentioned qualifications. On the basis of the Woodland study a double mailing to 3 times the panel size would have to be made. This required 1800 families randomly selected and proportionately distributed among the 17 strata. A comparison of the responses for the two cities is given in Table 3. Although the total response was significantly higher for Woodland, 74% as against 64% for Sacramento, there was no essential difference in 'active' response. Difference in responses was attributable to the 'inactive' response. Either the higher rate of transiency in Sacramento is the cause for more letters to be lost by way of leaving the city to other forwarding addresses or less forwarding addresses are furnished by those who move out of Woodland.

Mail response for Sacramento by socioeconomic group. The 17 areas in Sacramento were grouped into

TABLE 3

Comparison of mail response Woodland vs. Sacramento

	1st mailing		2nd mailing		Total	
	Wdland.	Sacto.	Wdland.	Sacto.	Wdland.	Sacto.
Families mailed					600	1800
Total response (% of total)	44	40	30	24	74	64
'Active' response[1]	40	37	22	22	62	59
'Inactive' response[2]	4	3	8	2	12	5

[1] 'Active' response refers to an actual return of recruiting card, regardless whether the respondent was eligible for the panel.

[2] 'Inactive' response refers to those letters returned unopened by the post office, unclaimed.

TABLE 4

Total response to Sacramento mailing by socioeconomic area

	Percent response		
	Total	Active	Inactive
High income—Group A			
Area 6	64	63	1
Area 12	72	68	4
Area 16	87	87	..
Average Group A	71	68	3
Upper middle income—Group B			
Area 5	55	53	2
Area 8	69	66	3
Area 9	65	62	3
Area 13	70	65	5
Area 17	58	55	3
Average Group B	65	61	4
Lower middle income—Group C			
Area 4	66	58	8
Area 7	60	57	3
Area 10	67	60	7
Area 11	72	70	2
Area 15	55	49	6
Average Group C	64	59	5
Low income—Group D			
Area 1	52	42	10
Area 2	41	34	7
Area 3	50	41	9
Area 14	59	53	6
Average Group D	49	41	8

4 socioeconomic area levels according to median yearly family income. The responses within each area and group are given in Table 4. It is to be noted that the percentage response to mailing increases with the level of income group. This observation has been made in other surveys *(3)*. Also, the inactive response increases with the group of decreasing income, demonstrating the greater population flux at lower incomes.

Comparison of eligible recruits from first and second mailing. The qualified respondents (family income between $3,000 and $10,000 and willing to participate) were classified as (a) use wine once or more times a week, (b) use wine 1 to 3 times a month, (c) use wine 1 to 5 times a year and (d) never use wine. The percentages in each category derived from the first and second mailing are given in Table 5. From the table, it is observed that the first mailing draws a higher response from those who are users of wine; the second mailing serves to recruit those who delay or hesitate and, brings in a higher proportion of *infrequent* and *never* users of wine. It is to be noted that the total number of qualified families given by the table does not represent the final panel as some of those in category 1 were later rejected to conform to the 25% limitation, and some other rejections were made for various reasons at the interview level.

TABLE 5

Percentage of qualified families, by category of wine usage, obtained from first and second mailing in Sacramento

	First mailing	Second mailing
Total families qualified	524	275
By category of usage	*Percent*	*Percent*
1—Use wine one or more times a week	42.	20.
2—Use wine 1 to 3 times a month	34.	23.
3—Use wine 1 to 5 times a year	16.	35.
4—Never use wine	8.	22.

TABLE 6

Comparison between standard and simplified recruiting letter for Area 2, Sacramento

	First mailing only	
	Standard letter	Simplified letter
Number of families	59	100
	% of total	*% of total*
Qualified for panel	14	13
Reject		
Moved	3	6
Income under $3,000	2	14
Income over $10,000	....	1
Total response	19	34

Effect of type of recruiting letter on response. A very low response was obtained from Area 2 (Table 4), a low income area. It was believed that the standard University recruiting letter may not have been understood by some of those in this region. Therefore, a new mailing was made to an independent sample of 100 families in this area, using a simplified form of the letter. A comparison of single mailing response between the standard and simplified letter is given by Table 6. The total response improved by the use of the simplified form (34%), as against the standard letter (19%). However, the increase was practically all due to those families earning less than $3,000 yearly. For the purpose of this study no gain in eligibles would be achieved by simplification of the recruiting letter. Any other study wishing to utilize all available families without qualification would necessarily have to consider the type of letter to be used in order to reduce non-response.

Effect of recruiting agency on response. As the response was a great deal higher than that from the usual trade survey, it was thought that the participation of the University might be at least partially responsible. To check this, a post-test was made substituting the Wine Advisory Board, a trade organization, for the University.

An independent sample was taken, consisting of 200 families randomly selected and stratified by areas, and a recruiting appeal was made in the same manner as that used when the University was the survey

TABLE 7

Effect of recruiting agency on response in Sacramento

	University letter[1]	Board letter[2]
Number of families	1800	200
	% of total	*% of total*
Active response	59.4	48.5
Inactive response	4.4	6.0
Total response	63.8	54.5
Summary of total response		
Qualified for panel by category		
1—Use wine one or more times a week	15.3	14.5
2—Use wine 1 to 3 times a month	13.6	10.0
3—Use wine 1 to 5 times a year	10.0	8.5
4—Never use wine	6.5	3.0
Moved	4.4	5.0
Deceased	0.5	1.0
Income under $3,000	6.5	5.0
Income over $10,000	5.0	6.5
Other reasons	2.0	1.0

[1] University of California
[2] Wine Advisory Board

agency. The comparison in response between the two agency letters is given in Table 7. The University letter yielded a significantly higher total response, 63.8%, than that of the Board letter, 54.5%. The main difference was in the active response. Also, the University letter produced a significantly greater percentage response, 6.5%, compared to 3%, from those who never used wine, category 4. These findings, however, would not preclude the use of the Wine Advisory Board as a recruiting agency since it did effect an active response of 48.5%.

SUMMARY

Participation in a consumer survey may depend upon the item to be tested. A study on grape wine would be expected to provide less incentive than other better known and accepted items. However, the recruiting procedure described produced a gratifying degree of volunteers which included a high proportion of regular users of wine. The objective of this procedure was to obtain two probability samplings of families, 25% of whom were regular users of wine and all of whom had a yearly income between $3,000–$10,000. A pre-test was employed to determine the size and number of mailings necessary to obtain the required panel.

Two cities were used as locales for this study, Woodland and Sacramento, California. The panel was recruited by a double mailing to a random sample of families. Nearly all of the families eligible for the panel responded to the double mailing, with practically all of the non-response due to transiency or unwillingness to participate. For Woodland, a simple random sampling was used; in Sacramento, on the basis of known population characteristics, a proportionate, stratified random sample was taken.

In a comparison of the response from the two cities, it was found that the percentage of 'active' (actual return of recruiting card by a respondent) response was about the same in both cities, although Woodland had a higher proportion of unclaimed letters returned by the post office.

Among the points of interest, it was found that the response to mailing increases with areas of increasing economic level; that the first mailing tends to draw a higher proportion of respondents who are general users of wine; and that both the type of recruiting letter and agency have an effect on the response.

Acknowledgment

The authors wish to thank Dr. E. M. Mrak, chairman of the Department of Food Technology, for his assistance in the preliminary work leading to the study.

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Method for Fly Egg Counts in Tomato Products

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(Manuscript received January 28, 1958)

AN IMPORTANT ATTRIBUTE of tomato products is relative freedom from eggs and maggots of the vinegar fly. Egg counts are made continuously in most tomato processing plants as a guide to *Drosophila* control measures and as assurance that the products are in compliance with Federal and State food law requirements.

The standard method is that of the Association of Official Agricultural Chemists *(1)*, whereby the comminuted product is shaken with gasoline and diluted about twenty-fold with water in a separatory funnel. The eggs are allowed to settle out for an hour, draining off the bottom liquid and re-stirring every 15 minutes. The liquid is filtered through a disk of bolting cloth on which the count is made under a low-power microscope. An additional hour of settling is required if eggs are found.

Effectiveness of the official procedure depends on how successfully the eggs can be freed from the mass of fibrous and gelatinous tomato material that rises with the gasoline emulsion toward the top of the funnel. With certain samples this layer is too dense and viscous to allow the eggs to settle freely.

One factor is the variable quantity of tomato material introduced with different samples. The A.O.A.C. method specifies a 100-g. sample regardless of the type of product. With tomato paste this amount may furnish as much as 40 or 50 g. of tomato solids, but with tomato juice only 6 g. of solids. Variations in the suspended layer are correspondingly great. To reduce excessive amounts of tomato material, some laboratories dilute their paste and puree in a manner corresponding to the A.O.A.C. procedure for mold counts before taking their 100-g. samples. It would be advantageous to base all egg counts on a standard amount of tomato material, such as the 8.5 to 9.5 g. of tomato solids that such dilution gives.

Another important variable is the pectin content of the samples. With products high in pectin, the large amount of gelatinous material not only interferes with settling out of the eggs but makes the subsequent filtration very tedious. Several filter cloths may have to be used to accomplish filtration in a reasonable time. Furthermore the layer of gel and debris on the cloth may be so thick as to make counting slow and inaccurate.

A third variable affecting the success of the method is the degree of comminution of the product. The screen size of the comminutor, the rate of shearing and the previous heat treatment of the pulp all affect the size and character of the tomato particles *(4, 6)*. Fields, Ammerman, and Desrosier *(2)* found that simply homogenizing a sample of tomato juice rendered the A.O.A.C. procedure entirely ineffective in recovering eggs that had been added subsequent to the treatment.

Thus the official method works well with some samples but very poorly with others. Erratic results, coupled with the requirement of one or 2 hours of settling, have prompted several workers to develop other means of attempting to isolate the eggs *(2, 3, 5, 7)*. In our laboratory the principal features of the official method have been retained, but with modifications that have improved its reliability and facilitated the manipulations.

MODIFIED METHOD

In a 400-ml. beaker, mix 100 g. of catsup or tomato juice (in the case of puree or paste, first dilute to about 9% solids) with

100 ml. of warm water (ca 65° C.)

10 ml. of pectolytic enzyme solution (made up daily, stir-6 level tsp. or 30 g. of Takamine Laboratory's Pektizyme Concentrate for two minutes in 200 ml. of 0.5% potassium oxalate solution, filtering or decanting).

Let stand 15 minutes for enzyme digestion. Transfer to a two-liter separatory funnel, rinsing beaker well. Add 30 ml. of gasoline and thoroughly shake contents. Add warm water up to the wide portion of funnel and agitate well by swirling and inverting the funnel several times. Rinse down the upper sides and stopper with a wash bottle. Let stand for 45 minutes, drawing off about 50 ml. of bottom liquid and swirling gently every 10 or 15 minutes. Draw off about 100 ml. more, filter through 8XX bolting cloth and count in the usual manner. If eggs are found continue another 30 minutes.

DISCUSSION AND RESULTS

The principal variance from the official procedure lies in digesting the tomato pulp with pectolytic enzyme before adding the gasoline and the dilution water. This effects a marked thinning of the tomato material, reducing the tendency of eggs to be trapped in the upper layer. Since most of the pectinic gel is destroyed, clogging of the cloth is obviated to the extent that 200 or 300 ml. of liquid can be filtered readily on a single cloth. With samples particularly high in pectin some gel may remain. Presumably this is largely calcium pectate, as its formation is reduced in the presence of oxalate or calcium-chelating agents. The coarser 8XX bolting cloth permits faster filtration than the 10XX specified in the A.O.A.C. method, and yet easily retains the eggs. A settling period of 45 minutes, plus another 30 minutes if eggs are found, appears adequate to free most of the eggs.

Table 1 offers a comparison of the two methods in 15 samples of catsup, puree, and paste. The average filtering time was shortened to almost a third and

TABLE 1

Filtering and counting times and egg counts, enzyme vs. A.O.A.C. method

Sample	Filtering time (sec.)				Counting time (min.)				Egg and maggot counts			
	1st period		2nd period		1st period		2nd period		1st period		2nd period	
	AOAC	Enz.	AOAC	Enz.	AOAC	Enz.	AOAC	Enz.	AOAC	Enz.	AOAC	Enz.
Catsup	58	48	45	33	10.0	9.0	7.0	4.0	5	9	1	0
	150	35	100	26	11.5	9.8	9.0	6.5	7	6	0	1
	420	43	135	35	55.5	11.0	13.0	4.5	0	7	0	0
	100	23	90	21	25.5	11.5	9.0	3.5	8	10	1	0
	45	19	14	15	7.3	7.2	3.3	2.8	12	12	0	0
	35	19	20	23	8.5	8.0	4.5	4.0	5	4	0	0
	28	28	43	24	9.0	7.7	7.3	3.0	2	7	0	0
Puree	100	22	12	11	13.5	7.5	3.3	2.1	0	1	1	0
Paste	48	25	30	20	7.0	8.0	4.0	3.0	1	3	0	0
	125	35	38	30	20.0	8.0	5.0	3.5	1	1	0	0
	56	68	44	31	5.6	2.5	1.8	1.7	1	1	0	0
	125	23	40	18	19.0	7.5	7.0	3.5	0	2	0	0
	85	20	45	18	24.0	10.0	7.0	2.5	1	3	1	0
	35	20	18	15	15.5	9.5	6.0	3.0	2	4	0	0
	16	12	13	7	5.4	4.9	2.3	1.5	2	6	0	0
Averages[1]	95.1	29.3*	45.8	21.8*	13.8	8.1*	6.0	3.3**			3.40	5.13*
Totals, Enz./AOAC	30.8%				52.3%				150.9%			

* Difference significant at the 5% level.
** Difference significant at the 1% level.
[1] Averages for egg and maggot counts (3.40 and 5.13) represent total recovery from both periods.

counting time to almost half that of the conventional method, whereas 50% more eggs were obtained. In the most difficult sample of this series, a high-pectin catsup, the A.O.A.C. procedure required a total of over 9 minutes for filtration and over an hour for counting. By the enzyme modification, filtration required a total of only 1¼ minutes and counting 15½ minutes. No eggs were obtained by the A.O.A.C. method; 7 eggs by the enzyme treatment.

SUMMARY

The conventional A.O.A.C. method for isolating and counting fruit fly eggs in tomato products varies in effectiveness with samples of differing character. The consistency of results has been improved and the procedure facilitated by modifications that include a preliminary enzyme digestion of the tomato material.

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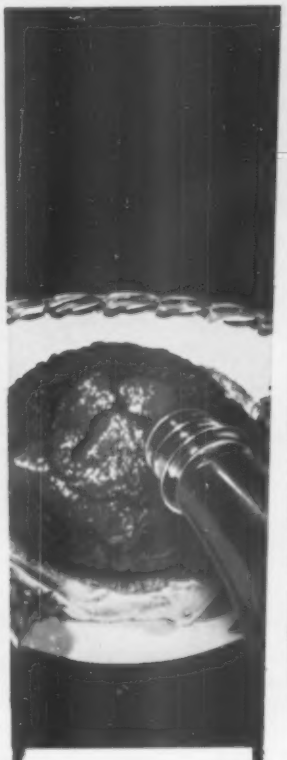

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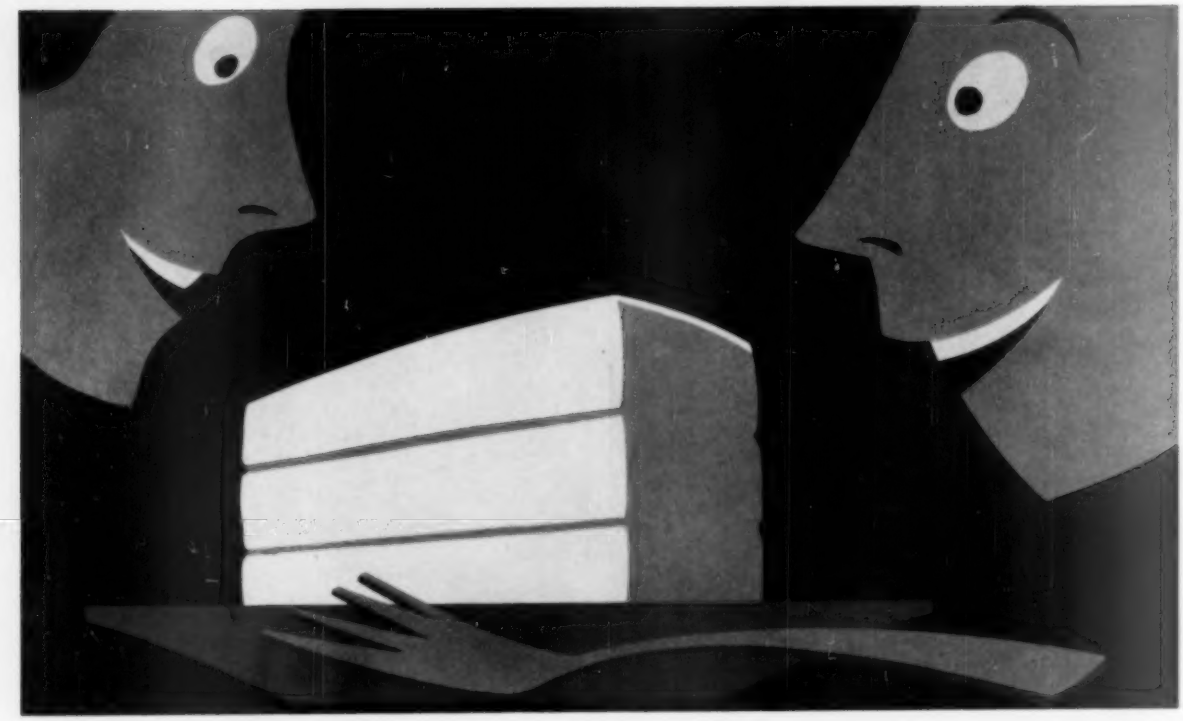

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Some Effects of Sweeteners on Frozen Fruits Used for Preserve Manufacture[a]

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(Manuscript received November 16, 1957)

PREVIOUS WORK in this department on the effect of sweetening agents on frozen strawberries utilized a small taste panel and indicated, but did not conclusively demonstrate, that sucrose-capped berries yielded preserves of superior flavor *(1)*. The uncertainty of this conclusion was heightened by the fact that a sugarless pack had not been included in the experiment. In addition, it is generally accepted that small "expert" panels may be excellent for difference studies but large panels are more reliable for preference studies. Accordingly, it seemed advisable to extend the work to include flavor evaluation by a large student panel and to incorporate a sugarless pack.

Because an acceptable sugarless pack might have substantial industrial implications, two additional fruits were included in these studies:

The susceptibility of cherries to browning indicates that severe changes in color, and perhaps in flavor as well, take place rapidly. If a specific sweetener were more efficient than others in preserving color and flavor, this effect might show up more strikingly in the sensitive reactive systems of cherries.

Processing peaches usually involves peeling, slicing, and other extensive handling before freezing. Slicing exposes more of the interior of the fruit to the action of the sweetener and provides a greater surface at which color degradation or flavor deterioration can take place. For these reasons, and because the yellow peach color is difficult to retain in preserve manufacture, peaches were used also in these experiments. Thus, the work reported here includes strawberries, cherries and peaches, packed with different sweeteners prior to freezing. Certain quality characteristics of the thawed fruits, and preserves made from these fruits, were measured after various storage periods and compared.

EXPERIMENTAL PROCEDURES

Strawberries. One lot of Marshall berries grown by one grower in the same field was used in these experiments. Thirteen different treatments were applied as explained in Table 1. Processing procedures, chemical determinations, drained weight determinations and preserve manufacturing procedures and evaluation were those described previously *(1)*. In addition, at the end of 8 months' storage two 10 lb. cans of each of the S-4, F-4, S-9, F-9 and "no sugar" treatments were processed into preserves. These were evaluated for flavor only.

The color of the berries immediately after thawing, and that of the preserves, was measured on the Hunter Color and Color Difference Meter, using the "L" scale. A representative sample was placed in a circular transparent clear plastic dish, and the dish rotated as described by Bockian and Hirzel *(2)*. The National Bureau of Standards red plaque SKC-70 was used as the standard.

TABLE 1

Different treatments used in preparing the frozen fruits

Treatment code	Sweetener used	Fruit : sweetener ratio
S-4	100% Sucrose	4 : 1 hand mixed
SD-4	75% Sucrose and 25% Dextrose[1]	4 : 1 hand mixed
SF-4	75% Sucrose and 25% Frodex	4 : 1 hand mixed
F-4	100% Frodex	4 : 1 hand mixed
S-6	100% Sucrose	6 : 1 hand mixed
SD-6	75% Sucrose and 25% Dextrose	6 : 1 hand mixed
SF-6	75% Sucrose and 25% Frodex	6 : 1 hand mixed
F-6	100% Frodex	6 : 1 hand mixed
S-9	100% Sucrose	9 : 1 capped
SD-9	75% Sucrose and 25% Dextrose	9 : 1 capped
SF-9	75% Sucrose and 25% Frodex	9 : 1 capped
F-9	100% Frodex	9 : 1 capped
No sugar	none	.....
L-4[2]	100% Lactose	4 : 1 hand mixed
L-9[2]	100% Lactose	9 : 1 capped

[1] As Cerelose, trade name of a product manufactured by the Corn Products Refining Company, New York, N. Y.
[2] Used only with peaches.

A panel of 120 untrained student judges was used in an incomplete block design to evaluate the different preserves according to flavor preference and acceptability. The incomplete block design allowed each sample to be evaluated an equal number of times without risking taster fatigue. For all tests except strawberry preserves manufactured after 8 months' storage each judge was given a tray containing two samples. The S-4 treatment, a standard commercial pack, was labeled 'R' and used as a reference. The other cup was labeled with a 3-digit random code number and contained the unknown. As part of the experiment, the S-4 treatment was also scored against itself as an unknown. The judge was asked to rate his like or dislike of the coded sample in direct comparison to the reference sample (Figure 1). Samples were scored from a low of 1 (much poorer flavor) to a high of 7 (much better flavor). The center point on the scale, 4, indicated that the sample was neither better nor poorer than the reference. Score points assigned to the terms (for statistical purposes) are shown in parentheses before the terms in Figure 1. These score points did not appear on the original ballot.

The ballot used to evaluate strawberry preserves made after 8 months' storage was that developed by Peryam and Girardot *(5)*. Each sample was randomly coded with a 3-digit number and an incomplete block design was used. Each taster received 3 samples per tray. The scale was later scored from 1 to 9; the center point was 5.

Cherries. One lot of Montmorency cherries grown by one grower in the same orchard was used in these experiments. The day after picking, the cherries were pitted, packed in 10-lb. friction top cans at a local commercial cannery, and then transported in a few minutes to the Department of Food and Dairy Technology at Oregon State College where the re-

[a] Technical Paper No. 1084, Oregon Agricultural Experiment Station. This project was financed in part by a grant from the Sugar Research Foundation, Inc.

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quired sugar was added as quickly as possible. Treatments were the same as those applied to the strawberries (Table 1). Very little browning of the cherries was visible during the entire processing operation. Treated cherries were frozen and stored at 0° F. until inspected.

Total acidity, pH and color of the cherries were determined at intervals during packing. The pH varied from 3.45 to 3.60 and the total acidity from 2.04 to 2.27% expressed as malic acid. Color values are given in Table 4.

Date:_____ Product:_____ Name_____

INSTRUCTIONS:

The side dish contains a reference sample. **Compare the flavor of each sample directly with the flavor of the reference sample.**

(a) Taste the reference and the sample as many times as necessary;

(b) Write the number which is on sample container in a space after the statement which indicates your judgment:

(7) Much better flavor than reference				
(6) Moderately better flavor				
(5) Slightly better flavor				
(4) Neither better nor poorer flavor				
(3) Slightly poorer flavor				
(2) Moderately poorer flavor				
(1) Much poorer flavor than reference				

Comments:

Figure 1. Flavor test ballot.

After the frozen cherries had been stored for periods of 3 and 6 months, drained weights and color were measured as described previously *(1, 2)*. Six 10-lb. cans of the 8-4 treatment and two 10-lb. cans of each of the other treatments were separately made into preserves. These preserves were evaluated for color and flavor as described above. Before being cooked, cherries were crushed slightly with a rolling pin to facilitate sugar penetration and prevent "floating." Pectin (100 grade), equivalent to 0.75% of the total sugar, was added to the fruit and sugar and the entire mixture boiled in a stainless steel, steam-jacketed, open kettle to an endpoint of 68° Brix.

Peaches. Ripe Elberta peaches were packed at a nearby cannery. Peaches were taken from the "sliced peach line" after they had been blanched in steam for 75 seconds, skinned, pitted and sliced. Slices were dipped in a 2000 p.p.m. SO_2 solution for approximately 2 minutes to retard browning, and then drained and mixed with the appropriate sugars as described in Table 1. The fruit was packed in 10-lb. friction-top cans, frozen at −35° F., and stored at 0° F. until examined. Because of the packing conditions, no initial measurements were made.

After the frozen peaches had been stored for periods of 3 and 6 months drained weights and color were measured as indicated above for cherries. The SBC-35 plaque was used as a color standard. Six 10-lb. cans of the 8-4 treatment and two 10-lb. cans of each of the other treatments were separately made into preserves. These preserves were evaluated for color and flavor by the previously described methods.

For preserve manufacture the peaches were thawed, chopped into small pieces, pectin (100 grade) equivalent to 0.5% of the total sugar added and the entire mixture cooked in a stainless steel steam-jacketed open kettle to an endpoint of 65° Brix.

RESULTS

Effect on Drained Weights

Strawberries. As indicated previously *(1)* the ratios have a pronounced effect upon the drained weights. As before, the 9:1 cap gave higher drained weights than either hand-mixed ratio, but the no-sugar treatment gave the highest drained weights of all. Last year's observations on Frodex were not confirmed. Apparently, the drained weight obtained with Frodex is a function of the care with which it is mixed with the berries and the degree to which the fruit disintegrates. After 6 months' storage, all the packs showed drained weights almost identical to those at the end of 3 months. Analysis of variance showed no significant difference due to time or sugar, but only to ratios. Examination of the frozen 6:1 and 4:1 packs showed a heavy concentration of syrup at the bottom of the cans. This suggests that the osmotic effect of the sugar took place before freezing occurred, and that very little change occurred during storage or thawing.

Cherries. Drained weight was affected by ratio only after 3 months' storage, but by both sugar and ratio after 6 months' storage. For any given sugar the 9:1 cap gives the highest drained weight followed by the 6:1 then 4:1 treatments. Table 2 shows that after 6 months' storage the Frodex treatment yielded the lowest drained weights within any given ratio. The no-sugar treatment after 6 months' storage was comparable to the 9:1 Frodex cap, and yielded a higher drained weight than any of the handmixed treatments except sucrose 6:1.

TABLE 2

Per cent drained weights of thawed cherries and peaches after 3 months and 6 months storage

Treatment	Cherries		Peaches	
	3 months	6 months	3 months	6 months
S–4	70.6	70.5	66.6	69.0
SD–4	70.5	70.6	65.4	69.5
SF–4	67.5	68.4	65.6	66.5
F–4	63.3	63.2	66.1	68.5
S–6	74.5	76.3	73.0	74.6
SD–6	73.0	73.7	74.5	75.5
SF–6	70.7	70.8	71.5	74.0
F–6	67.5	68.6	71.3	72.0
S–9	77.2	75.3	72.8	74.5
SD–9	76.0	79.3	72.5	72.5
SF–9	75.0	77.6	71.3	73.5
F–9	75.2	74.5	73.4	74.0
None	71.7	74.8	79.4	82.0
L–4	.....	.....	73.4	78.5
L–9	.....	.....	72.9	75.0
L.S.D. (.05)		3.30		2.49
(.01)		4.47		3.38

Peaches. After 3 months' and 6 months' storage the 4:1 ratio, with the exception of the lactose treatment, yielded the lowest drained weights. Capping the fruit resulted in approximately the same drained weight as hand-mixing with sugar at a 6:1 ratio. On osmotic considerations alone the lactose and sucrose treatments should yield equivalent results; the higher value for the lactose treatment is probably due to the insolubility of some of the lactose in the syrup surrounding the peaches. The lactose cap yielded drained weights in line with those obtained by capping with other sugars. The no-sugar treatment yielded the highest drained weights. Table 2 shows some typical means.

Effect on Hunter Color Values of the Thawed Fruit

Strawberries. Table 3 shows that the Hunter "L" values after 3 months' storage all fell within the values determined for the fresh berries. The "L" values for the no-sugar treatment are significantly lower than those for sugar treatments, but still within the range scored high for color by Agricultural Marketing Service standards *(6)*. The Hunter "a_L" values after 3 months' storage rose slightly from those of the

TABLE 3

Hunter color values of thawed strawberries and strawberry preserves[1]

Treatment	3 Months storage								6 Months storage							
	Thawed berries			Change on storage ΔE	Preserves			Change on processing ΔE	Thawed berries			Change on storage ΔE	Preserves			Change on processing ΔE
	L	a_L	b_L		L	a_L	b_L		L	a_L	b_L		L	a_L	b_L	
S–4	17.5	22.1	8.2	2.58	11.7	7.0	3.4	16.9	19.3	29.3	11.3	10.4	10.6	9.3	8.7	22.0
SD–4	18.4	22.0	8.7	2.59	11.0	7.1	3.2	17.5	19.2	29.6	12.1	10.9	11.3	9.0	8.9	22.3
SF–4	17.0	21.7	7.7	2.33	11.1	6.8	3.2	16.6	18.6	27.8	11.4	9.0	10.8	9.4	8.5	20.2
F–4	18.3	21.0	8.5	1.64	11.2	6.8	3.2	16.4	21.2	30.2	12.5	12.0	11.2	9.5	8.5	25.1
S–6	16.7	20.4	7.8	1.71	11.4	7.1	3.4	15.0	19.2	28.7	11.9	10.1	10.3	9.3	8.5	21.8
SD–6	17.0	21.5	8.0	2.16	10.8	6.7	3.0	16.8	19.0	29.3	12.0	10.6	10.9	9.0	8.4	22.1
SF–6	17.9	22.9	8.4	3.35	11.3	6.8	3.3	18.1	19.3	29.1	12.0	10.5	10.7	9.4	8.5	21.8
F–6	19.7	22.2	9.3	3.41	11.4	7.0	3.4	18.3	20.2	29.5	12.2	11.1	10.8	9.4	8.6	22.5
S–9	18.1	22.4	8.6	3.01	10.6	7.0	3.4	17.9	19.8	29.0	12.3	10.6	10.3	9.3	8.5	22.2
SD–9	16.8	20.4	7.5	1.47	11.4	7.0	3.3	15.1	18.6	29.2	12.0	10.4	10.6	8.9	8.4	22.1
SF–9	17.8	21.0	8.0	1.43	11.5	6.9	3.6	16.1	19.8	30.0	12.3	11.5	10.0	8.3	8.5	24.1
F–9	17.2	20.9	7.8	1.53	11.9	7.3	3.5	15.2	20.0	30.3	12.3	12.3	10.1	9.0	8.6	23.8
No sugar	16.2	21.4	7.2	2.06	11.7	6.9	3.5	15.6	18.2	28.3	11.7	9.5	10.4	8.0	8.2	22.0

[1] L, a_L and b_L mean values and standard errors for 6 samples of fresh berries were: 18.0 ± 0.7, 19.6 ± 1.0, and 7.8 ± 0.5. The range was 16.2 to 20.1, 17.0 to 23.0, and 6.5 to 9.6.

fresh berries, the respective averages being 21.2 and 19.6. The Hunter "b_L" values also rose after 3 months' storage from 7.8 to 8.5. Here again, the no-sugar treatment at 6.9 was significantly lower than the other samples, although still within the range of values of the fresh berries.

After 6 months' storage, all the treatments showed higher "L" values than the original berries. The average of all the sweetener treatments was 19.5; the original berries were 18.0, and the no-sugar treatment was 18.2. The Hunter "a_L" values increased markedly to 29.3 and the "b_L" to 11.9. According to Hunter *(3)*, increased "a" values indicate a shift toward the red and away from green, increased "b" values a shift toward yellow and away from blue. Table 3 shows how each treatment deviated from the mean values of the original berries when the ΔE treatment *(3, 4)* is used. ΔE, defined as $\sqrt{\overline{\Delta L}^2 + \overline{\Delta a_L}^2 + \overline{\Delta b_L}^2}$, is a measure of the degree of color difference between samples; ΔE greater than 1 indicates a visually discernible difference. The ΔE values of the original berries varied from the mean by 0.58 to 4.29 ΔE units.

Cherries. The Hunter "L", "a_L", and "b_L" values for the fresh cherries, and thawed cherries after 3 and 6 months' storage are given in Table 4. Each value for fresh cherries is the result of determinations on duplicate composite samples from 4 cans. Initial color values for the capped fresh cherries were considered to be the same as those of the unsugared treatments. The over-all color change during storage is calculated in ΔE units *(3, 4)*. As with strawberries, the major portion of the color change after 6 months' storage is due to an increase in the "a_L" and "b_L" values.

Peaches. Color values for thawed peaches after 3 months' and 6 months' storage are shown in Table 5. A representative sample of fresh peaches had a Hunter "L" value of 26.0, "a_L" of 11.8 and "b_L" of 22.6. Immediately after sulfiting, the Hunter values on a duplicate sample were 14.6, 9.6 and 18.5, respectively. Undoubtedly the extremely high "L" (lightness) values after storage are due to the prolonged bleaching effect of sulfite. The lactose treatments yielded "L" values significantly higher and "a_L" and "b_L" values significantly lower, than those obtained with other treatments. The high "a_L" value for the S-4 treatment after 3 months' storage seems anomalous and disappears at the end of 6 months' storage.

Effect on Color Values of the Preserves

Strawberries. The Hunter "L", "a_L", and "b_L" values for the strawberry preserves made from berries kept in frozen storage for 3 and 6 months are given in Table 3. The greatest change in preserves made at the end of the storage intervals is the "a_L" and "b_L" values. These reflect changes in the thawed berries. However, the "L" values of the preserves made from the capped and no-sugar treatments after 6 months' frozen storage are less than after 3 months' storage, although the "L" values on the thawed berries show the opposite effect. This would indicate that hand-mixed treatments are slightly less susceptible to color change during processing. Changes during processing are expressed in ΔE units.

Cherries. The Hunter "L", "a_L" and "b_L" values for cherry preserves made from fruit kept in frozen storage for 3 and 6 months are listed in Table 4. As with strawberries, the high "a_L" and "b_L" values of the thawed fruit appear in the preserves. Unlike strawberries, however, the higher "L" values of the thawed fruit also appear in the preserves. The overall color change is expressed in ΔE units.

Peaches. Table 5 shows that preserves made from peaches kept in frozen storage for 3 and 6 months do not reflect the color differences noted in the thawed fruit. The high "a_L" values noted for the thawed peaches of the S-4 treatment after 3 months' storage were not evident in the preserves made from

TABLE 4

Hunter color values of fresh and thawed cherries and cherry preserves

Treatment	3 Months storage											6 Months storage							
	Fresh cherries			Thawed cherries			Change on storage ΔE	Preserves			Change on processing ΔE	Thawed cherries			Change on storage ΔE	Preserves			Change on processing ΔE
	L	a_L	b_L	L	a_L	b_L		L	a_L	b_L		L	a_L	b_L		L	a_L	b_L	
S–4	16.2	13.5	6.2	15.9	18.3	7.1	4.9	10.8	8.2	3.6	11.8	16.4	26.0	13.4	14.4	10.9	10.3	12.9	16.6
SD–4	15.9	13.7	6.0	15.6	18.0	6.6	4.4	10.3	7.5	3.3	12.2	17.8	26.0	13.6	14.6	12.0	10.1	12.3	17.0
SF–4	17.0	15.9	6.9	15.8	17.6	7.0	2.1	10.4	8.6	3.4	11.1	17.1	26.4	13.4	12.3	12.4	10.4	12.2	16.8
F–4	16.6	13.9	6.5	16.6	18.0	7.4	4.2	10.4	7.7	3.2	12.7	18.9	26.5	14.0	14.8	11.8	10.5	13.2	17.6
S–6	16.9	14.3	6.7	15.8	17.8	6.6	3.7	10.5	7.6	3.3	11.9	17.2	26.2	13.4	13.7	11.9	9.8	12.2	17.3
SD–6	15.5	14.1	5.9	15.6	18.8	7.2	4.9	9.9	7.0	3.0	13.8	16.0	24.1	13.2	12.4	11.5	9.2	12.2	18.5
SF–6	16.7	13.4	6.1	15.0	17.1	6.6	4.1	10.3	7.1	3.1	11.6	17.9	27.0	13.6	15.6	12.1	9.5	12.0	18.5
F–6	17.4	14.2	6.8	16.5	18.6	7.5	4.5	10.3	8.3	3.4	12.7	18.6	27.1	13.6	14.6	11.8	9.6	12.3	18.8
S–9	14.8	10.2	5.1	15.2	18.6	6.7	8.6	10.1	6.8	3.0	13.4	17.0	25.0	13.2	17.0	11.7	9.3	12.2	16.6
SD–9	14.8	10.2	5.1	15.8	18.9	7.0	9.0	10.0	6.7	3.0	14.1	16.6	23.4	13.2	15.6	12.0	9.9	12.2	14.3
SF–9	14.8	10.2	5.1	15.6	18.9	7.1	9.0	10.3	7.4	3.4	13.2	16.8	25.6	13.1	17.4	11.7	9.7	12.2	16.7
F–9	14.8	10.2	5.1	16.2	19.5	7.1	9.6	10.2	7.2	3.3	14.2	18.8	27.9	13.2	19.9	12.5	10.5	12.1	18.5
None	14.8	10.2	5.1	17.6	19.5	8.2	10.5	10.4	7.2	3.5	15.0	18.8	28.5	13.5	20.5	12.5	10.6	12.3	18.9

TABLE 5

Hunter color values of thawed peaches and peach preserves

Treatment	3 Months storage						6 Months storage					
	Thawed fruit			Preserves			Thawed fruit			Preserves		
	L	a_L	b_L	L	a_L	b_L	L	a_L	b_L	L	a_L	b_L
S–4	56.0	12.9	30.3	21.4	2.4	8.8	56.6	6.8	30.9	21.3	2.4	8.6
SD–4	55.6	5.3	30.4	21.3	2.6	8.5	57.3	3.0	30.7	21.5	2.8	8.6
SF–4	57.6	7.1	31.0	21.1	2.8	8.3	57.0	5.9	31.2	21.2	3.1	8.3
F–4	57.9	5.8	31.7	23.3	2.2	9.2	53.7	6.0	29.0	27.4	2.2	9.2
S–6	57.7	6.4	31.0	21.3	2.7	8.9	57.8	5.9	30.5	21.3	2.7	8.9
SD–6	56.8	5.8	30.7	22.1	2.1	9.4	56.9	5.7	30.7	21.1	2.1	9.3
SF–6	58.0	7.8	31.3	21.5	2.7	9.1	56.8	6.5	30.8	21.5	2.5	8.9
F–6	56.9	8.2	30.6	21.3	3.3	9.0	56.9	5.8	30.9	21.3	2.7	8.9
S–9	57.9	7.9	30.8	21.4	3.0	8.7	56.1	8.6	30.3	21.6	3.2	8.8
SD–9	59.2	6.5	31.6	21.5	2.8	9.4	56.1	7.0	30.1	21.3	2.6	9.0
SF–9	60.1	6.5	32.2	21.2	2.0	8.9	58.0	7.7	31.5	21.2	2.2	8.9
F–9	57.2	6.4	30.4	21.6	2.6	8.8	53.4	6.1	28.0	21.4	2.4	8.8
No sugar	57.2	5.5	29.6	20.2	1.7	8.0	58.0	7.5	29.8	20.5	2.2	8.2
L–4	74.0	1.3	27.5	20.8	4.1	8.6	73.7	0.7	27.1	21.4	3.0	9.0
L–9	67.8	4.4	29.4	21.4	3.0	8.9	72.8	3.0	27.3	21.0	2.9	8.6

those peaches. Similarly, the high "L" values and low "a_L" for the peaches frozen with lactose were not reflected in the "L" and "a_L" values of the preserves. Because of the tremendous decrease in "L" values during processing, no ΔEs were calculated.

Effect on Flavor of the Preserves

Strawberries. Tests run on preserves made after 3 months' frozen storage indicate a dislike for the F-4 treatment; all other treatments were preferred equally. The taste panel had no preference or dislike for any preserve made from berries kept in frozen storage for 6 months. Taste-test results on the incomplete block experiment done after 8 months' storage with the following 5 treatments—S-4, S-9, F-4, F-9, and no-sugar—showed a barely significant dislike for the F-9 treatment. Results are shown in Table 6.

TABLE 6

Mean scores of flavor evaluation tests of strawberry and peach preserves

Treatment	Strawberries			Peaches	
	3 mo.	6 mo.	8 mo.	3 mo.	6 mo.
S–4	4.18	4.65	6.72	4.88	4.60
SD–4	4.38	3.94		3.81	4.79
SF–4	4.00	4.16		4.06	3.93
F–4	3.12[1]	3.90	6.85	4.44	4.31
S–6	4.36	4.15		4.12	4.13
SD–6	4.25	3.72		3.80	4.19
SF–6	4.02	3.61		3.53	4.36
F–6	4.00	3.76		4.31	4.33
S–9	4.43	4.22	6.62	4.00	3.75
SD–9	4.02	4.37		4.60	4.00
SF–9	3.77	4.26		4.60	4.14
F–9	4.14	4.00	6.34	5.29	3.17
No sugar	4.05	4.37	6.73	4.94	4.50
L–4	.....	.....		4.06	4.00
L–9	.....	.....		4.56	4.40
Grand mean	4.06	4.09		4.31	4.18
L.S.D. (.05)			0.35	0.80	0.88
(.01)			0.46	1.05	1.07

[1] Responsible for all significant effects due to sugar or ratio.

Cherries. Tests run on preserves made from cherries after 3 and 6 months' storage, showed no preference for any treatment.

Peaches. Preserves made from peaches after 3 months' frozen storage were significantly different due to sugars and to sugar-ratio interaction, and highly significantly different due to treatments and fruit : sugar ratio. The Frodex cap ranked higher than all the other treatments. Preserves made from peaches after 6 months' frozen storage were significantly different due to fruit : sugar ratio only. The score for 6 : 1 ratio was higher than at 3 months, but the score for the 9 : 1 cap was lower. The Frodex cap treatment now ranked lowest. Preserves made from the no-sugar treatment ranked above the grand mean at the end of each storage period (Table 6).

Vitamin C Content of Frozen Strawberries and Preserves

No significant differences in vitamin C content were found in the frozen berries or preserves due to treatments, sweeteners or ratios used. The no-sugar treatment was slightly below average in the amount of vitamin C retained.

DISCUSSION

Strawberries. Results indicate that many sweeteners or no sweetener can be used in packing frozen strawberries which will be processed subsequently into preserves. Length of storage before the preserves are prepared might influence the choice of sweetener. For example, a Frodex 4 : 1 pack gave a low flavor score in preserves made after 3 months' storage, but a high score in preserves made after 8 months' storage. A Frodex 9 : 1 cap gave preserves of acceptable flavor scores after 3 months' and 6 months' storage. At the end of 6 months, however, the color changes during storage and processing were quite severe, whereas after 3 months' storage it was among the best of all samples tested in this respect. Although preserves made from berries which had been stored for 8 months after capping with Frodex scored significantly lower for flavor than the other treatments with which they were compared, they still ranked much higher than a score of 5.00, the center point on the scale. Considering flavor score and color retention, the S-6 treatment might be considered the best for packs to be processed within 3 months, but for processing at the end of 6 months the choice might be among S-4, SD-9, or no-sugar. The overall color change, from fresh berry to preserve, is shown in Table 7. The no-sugar pack scored average or better at all times in flavor of preserves, and slightly better than average at 3 months' and 6 months' for color change. As indicated previously *(1)*, the treatments were equal in retention of ascorbic acid, but the drained weights depended on the fruit : sugar ratio and may have depended on the sweetener also.

Cherries. Drained weights of cherries are a function of the fruit : sugar ratio; capped treatments yield the highest drained weights. The no-sugar treatment yields higher drained weights than any of the 4 : 1

TABLE 7

Over-all color change in strawberries and cherries after manufacture into preserves

ΔE units

Treatment	Strawberries		Cherries	
	3 months	6 months	3 months	6 months
S–4	14.8	13.1	8.0	9.1
SD–4	15.0	12.6	8.8	8.2
SF–4	15.0	12.5	10.4	9.1
F–4	15.2	12.2	9.4	8.2
S–6	14.8	12.9	9.9	8.7
SD–6	15.5	12.8	9.5	8.4
SF–6	15.1	12.6	9.5	8.9
F–6	14.9	12.8	9.8	9.1
S–9	15.3	12.9	6.2	7.8
SD–9	14.9	13.0	6.3	7.6
SF–9	14.9	13.9	5.6	7.8
F–9	14.4	13.2	5.8	7.4
None	14.8	13.9	5.6	7.6

packs and is about equal to the average of the 6:1 packs. Caps and no-sugar treatments show the greatest color changes during storage and processing. These changes are in opposite direction, however, and the resultant preserves are closer to the color of the original fruits than preserves made from other treatments (Table 7). The student panel found no difference in the taste of preserves made from any of the treatments. As with strawberries, a no-sugar pack yielded preserves of acceptable color and flavor.

Peaches. All the treatments of sulfited peaches yielded thawed products of acceptable appearance. Frozen peaches, whether capped, hand-mixed, or unsweetened, were a pleasing bright yellow color. Upon thawing, however, the material exposed above the level of the thawed exudate turned brown. In no case did this amount to more than the ends of about 10 slices. Presumably this browning can be prevented by covering the frozen peaches just prior to defrosting with a pad saturated with citric or ascorbic acids, or with sulfite. In no instance was there sufficient sulfite remaining in the preserves to affect the flavor. An examination of Tables 2, 5 and 6 indicates that the anticipated length of storage of frozen sulfited peaches might influence the choice of sweetener. The lactose and no-sugar treatments gave products of high drained weight and flavor scores and acceptable color at the end of either 3 months' or 6 months' storage; the F-9 and S-4 treatments gave excellent results after 3 months' storage.

SUMMARY AND CONCLUSIONS

Effects of different sweeteners and fruit:sugar ratios on some quality characteristics of Marshall strawberries, Montmorency cherries and Elberta peaches frozen for subsequent manufacture into preserves were investigated. Results show that ratios affect drained weights, and that certain treatments affect the flavor and color of some thawed fruits and their preserves. There is no clear-cut evidence for the superiority of any sugar in these respects.

A large student taste panel failed to confirm previous indications by a small panel that Marshall strawberries capped with sucrose and frozen for 6 months yielded better flavored preserves.

Fruits packed without sugar and frozen for periods up to 8 months were processed into preserves having a color and flavor equal to that of preserves made from sweetened packs.

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Dehydrated Cooked Meat Products[a, b]

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AT THE PRESENT TIME a wide variety of dehydrated foodstuffs is available for procurement by the Armed Services, or is in the final stages of development. Complete meals can now be served using dehydrated foods only. These products rehydrate quickly, and when cooked using conventional large or small scale equipment, are difficult to distinguish from fresh or frozen foods. The use of these dehydrated foods in bulk feeding can yield a significant saving in storage and transportation requirements. In addition, to reduce the need for non-combatant and kitchen personnel, dehydrated ready-cooked foods are under development which can be prepared without difficulty by inexperienced individuals. Typically these items are required to be ready for eating after soaking in hot (180–212° F.) water (or broth, gravy, etc.) or simmering for 10 minutes or less. It is also to be desired that, whenever possible, they should be acceptable when eaten dry.

Of commercial items, instant potatoes, rice and various soups rehydrate with the necessary rapidity. Recently the preparation of pre-cooked dehydrated bean products was described by Feldberg, Fritzche and Wagner *(5)*. Yao, Nelson and Steinberg *(12)* have prepared dehydrated cooked chicken pieces and Turner *(9)* has dealt in general terms with the future of dehydrated meat as a convenience food item. Work on the development of a wide variety of cooked dehydrated meat products is of the greatest importance.

Although cooked ground meat can be dehydrated in a hot-air type drier *(4, 7)* it is well recognized that vacuum freeze-drying is the only satisfactory method to dehydrate raw or cooked meat pieces such as chops or steaks *(1, 4, 7, 8, 11)*. So far, freeze-drying has not been used on any scale for the dehydration of foodstuffs because of the high processing cost involved which is very largely due to the long processing times required. Using the conventional hot shelf or infra-red heating type of drier, the rate of drying is limited by the rate of heat transfer to the product to provide heat of sublimation of ice *(3, 12)*. To increase the rate of drying it is necessary to increase the heat input and this must be done, of course, without causing the ice to melt or allowing the dried outer layers to overheat.

A convenient method of achieving this has been developed *(3)* in which, during the drying process, the meat slices are sandwiched between two spiked heater plates, so that heat is conducted through the spikes into the meat slices. Drying occurs not only from the surface but also around each spike, and raw or cooked meat slices can be freeze-dried in as little as 3–5 hours. In this laboratory, using such equipment, it has been found possible to dehydrate all foods previously dried by conventional freeze-drying and in addition, thick pieces may be dried without prolonging the drying time. The value of the process for the preparation of dehydrated cooked meat pieces is dealt with in this paper.

The present day preoccupation with vacuum drying methods for raw meat dehydration suggests the possibility that hot-air drying of cooked ground meat has been overlooked. The latter process has the advantage of being inexpensive. It can also be readily carried out on a large scale with equipment available in Canada and in other countries. Meat bars prepared from hot-air dried cooked beef and pork, and suitable for eating dry as well as after reconstitution, have been procured by the Canadian Armed Services for several years. A study has been made of the rehydration characteristics of hot-air dried cooked ground beef to determine its value as a typical "quick-serve" item.

EXPERIMENTAL

Preparation of cooked meat samples. Cooked meats were prepared for freeze-drying by dry heat (roasting) and by moist heat (pressure cooking). Standing rib roasts of beef were cooked in an oven at 325° F. until the internal temperature of the meat was 160° F. Pork loins were roasted until the internal temperature reached 170° F. Turkeys were boned and rolled and then cooked to an internal temperature of 170° F. These meats were then allowed to cool to 40° F., cut away from the bone when necessary, and sliced in ¼ in. slices before being placed on the drying plates.

Round steak and boiling fowl were both cooked in pressure cookers at 15 lb. pressure until tender, approximately 25 minutes for the steak and 30 minutes for the fowl. The degree of cooking in each case was found to be critical. If the meats were too well cooked, they fell to pieces when dried or, if they were underdone, the reconstituted meats were tough.

For the preparation of cooked ground beef, as described by Sharp *(7)*, 350 lb. of Canada Grade B beef comprising equal parts of round, loin and rib, and chuck, was cut into 2 inch cubes as free as possible from connective tissue, and cooked, in two batches, by simmering in a steam kettle for 30–35 minutes. About 5 gallons of water was added to the first batch, sufficient to cover the meat. The meat pieces were removed and ground through ⅜ in. holes and the gravy, evaporated to about 5 gallons, separated from the rendered fat then added back and mixed in before drying.

Freeze-drying. The basic equipment consisted of a Stokes' Industrial Model No. 2005 FX-4 freeze-drier evacuated by a 1.5 h.p. "Microvac" pump, capacity 32 cu. ft./minute. The vacuum chamber was fitted with drying shelves and two refrigerated plates maintained at about −40° F. by a 2 h.p. 1-stage freon compressor. Conventional freeze-drying was carried out at a shelf temperature of 100–115° F. and a pressure of about 1 mm.

Spiked plate units used for rapid freeze-drying were constructed from aluminum plates 16 in. x 12 in. x ¼ in. each fitted, on one side, with a 1 kw. heater and on the other with aluminum spikes 3/32 in. diameter, ½ in. apart between centres

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 15th, 1957.

[b] DRML Report No. 21–5. PCC Project No. D50–78–10–01.

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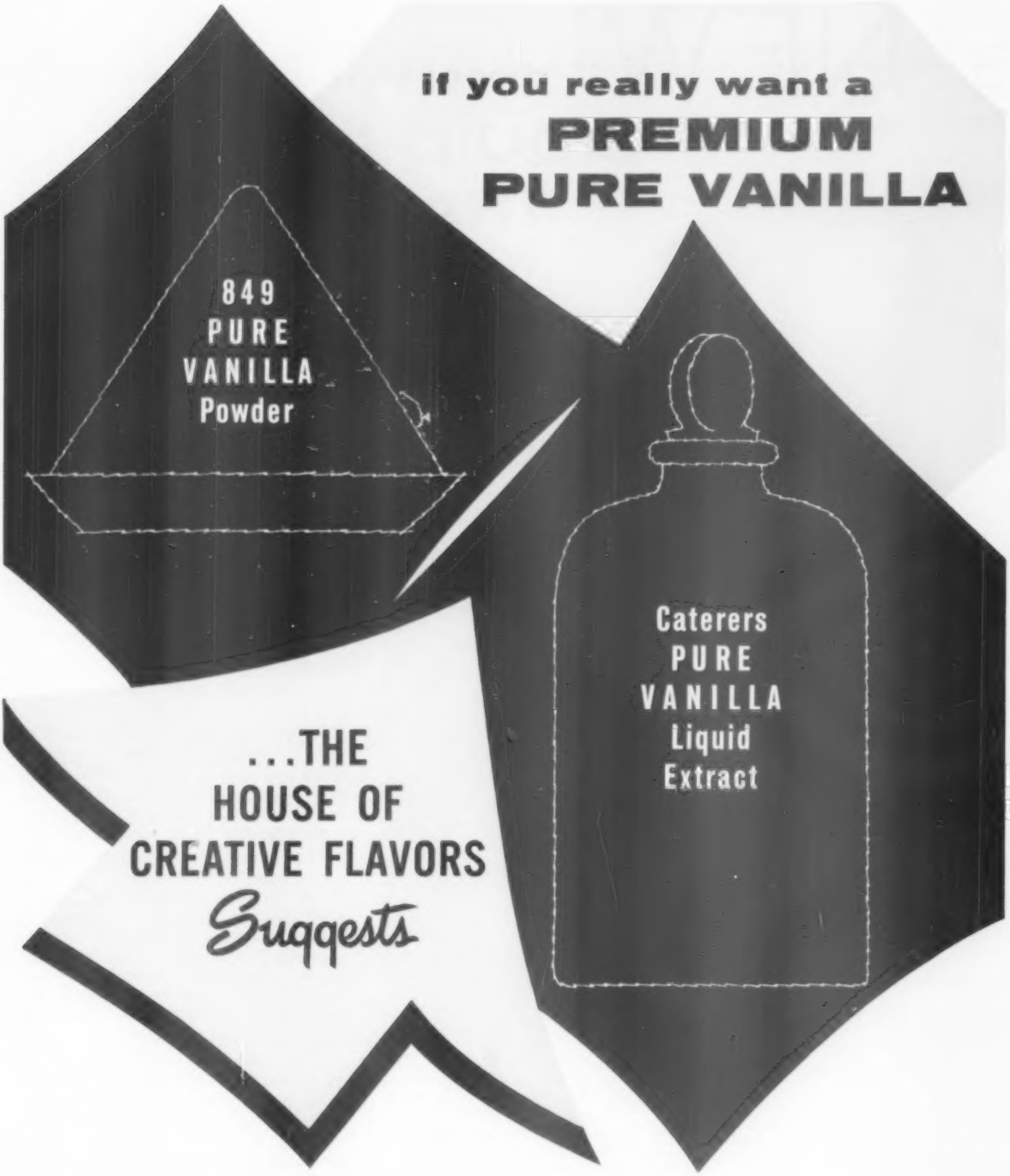

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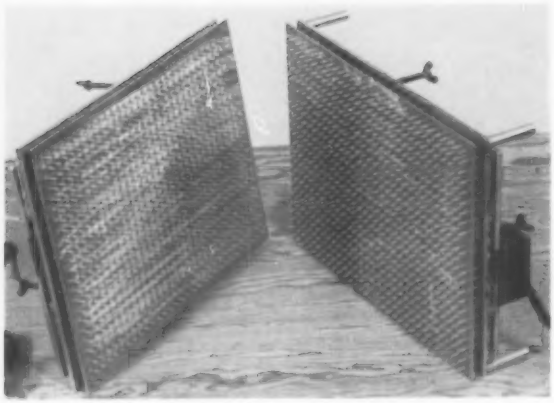

Figure 1. Spiked plate unit.

and projecting 1⅛ in. Stripper plates ¼ in. in thickness were drilled with holes through which the spikes fitted loosely and were used to facilitate the removal of the meat, when dry, from the plates (Figure 1).

Meat steaks, boneless chops, or piles of slices ½ to 1 inch in thickness were laid on the spikes of one plate and a second pressed on top so that spikes from top and bottom were uniformly spaced in the meat. Care was taken to avoid squeezing the meat slices between the plates. Each unit held about 4–5 lb. of meat, a maximum loading of over 3½ lb./square foot.

One or more units were placed in the vacuum chamber and the pressure reduced to about 1 mm. of mercury. No heat was applied for the first 15 minutes and then the temperature of the heater plates was allowed to rise over a period of about 1 hour to 120–140° F. At first the meat temperature fell to about 5° F. then after 1–1½ hours rose gradually to plate temperature, which was reached after a total of 3–4½ hours. Experience has shown that at this point the product is uniformly dry, devoid of wet patches and has an average moisture content of less than 2%.

Hot-air drying. This was carried out in a conventional centre exhaust type tunnel drier *(10)*. Cooked ground meat laid on galvanized iron trays at a loading of about 2 lb./square foot was dried at an air temperature of 180° F. for 1 hour, then at 160° F. for a further 2–3 hours. The linear air velocity over the trays was about 800 ft./minute.

Rehydration. Unless otherwise specified, products were rehydrated by soaking for 5 minutes in almost boiling 1% sodium chloride solution (200–210° F.) not allowing the temperature to fall below 180° F. during the experiment. The rehydration was determined by the gain in weight expressed as the percentage of initial water content of the cooked meat. Turner *(9)* has discussed the effect of salt solutions on the rate of rehydration of dried meat. Rehydration generally is more efficient in sodium chloride solution than in water.

Sensory ratings. Unless otherwise stated, 9-point scale ratings were used to evaluate products in taste panels and field tests. The laboratory taste panel was composed of 6–13 people experienced in testing dehydrated meat products. The hedonic scale *(6)* used to evaluate acceptability in Tables 2 and 3 was as follows:

1. Dislike extremely
2. Dislike very much
3. Dislike moderately
4. Dislike slightly
5. Neither like nor dislike
6. Like slightly
7. Like moderately
8. Like very much
9. Like extremely

RESULTS AND DISCUSSION

Freeze-dried meat. In the dehydration of raw meat it is the practice to freeze before placing in the drier. Freezing by evaporation causes a loss of meat juices, case hardening and, when spiked plates are used, a softening of the texture. Sensory tests, however, failed to show a difference between cooked meat items dehydrated after pre-freezing and those frozen under vacuum.

Table 1 gives some properties of freeze-dried cooked meat items prepared in this laboratory. When spiked plates are used there is little change in drying time

TABLE 1

Freeze-dried cooked meat items

Meat item	Thickness of slice	Conventionally freeze-dried		Freeze dried on spiked plates		Percentage rehydration	
		Average drying time	Ability to rehydrate	Average drying time	Ability to rehydrate		
	(inches)	*(hrs.)*		*(hrs.)*			
Braised beef round steak	¾–1	15–20	Complete	4	Complete	83–100	Acceptable meat flavour. Tender
Roast beef rib slices	1/16–¼	6–8	Fatty and connective tissue incomplete	4	Fatty and connective tissue incomplete	65–83	"Warmed up" roast beef flavour
Pan-fried beef loin steak	¾	.....		4	Incomplete at centre	38–58	Boiled beef flavour
Roast pork loin slices	1/16–¼	6–8	Very limited	4	Fatty tissue incomplete	53–84	Mild roast pork flavour
Roast turkey slices							
white meat	¼	8	Complete	4	Complete	93–111	
dark meat	¼	8	Connective tissue slow to rehydrate	4	Connective tissue slow to rehydrate	60–93	Typical roast turkey flavour and texture
Roast chicken slices							
white meat	¼–¾	8–15	Complete	4	Complete	84–95	
dark meat	¼–¾	8–15	Connective tissue incomplete	4	Connective tissue incomplete	65–85	Typical roast chicken flavour
Pressure cooked chicken							
white meat	¼–¾	8–15	Complete	4	Complete	91–110	
dark meat	¼–¾	8–15	Connective tissue slow to rehydrate	4	Connective tissue slow to rehydrate	65–95	Mild chicken flavour

with variations in total thickness of the meat slices up to at least 1 inch, and the short drying times may be coupled with a heavy plate loading. In conventional freeze-drying using single heated shelves (or infrared heating) the time of drying increases with the thickness, e.g. slices $\frac{3}{16}$ in. in thickness dry in about 6 hours while 15–20 hours is required for slices $\frac{3}{4}$ in. in thickness. It should be noted, however, that for the thin slices the loading density is only about $\frac{3}{4}$ lb./square foot and in terms of output per drying chamber, the advantage of the shorter drying time is lost.

During freeze-drying, rendered fat may soak into the dried layers and prevent subsequent rehydration. This happened in particular when roast pork loin slices were dried conventionally, and the heater shelves became covered with fat, but was less marked when spiked plates were used and the rendered fat allowed to drip away from the meat slices.

Dehydrated connective tissue was relatively slow to pick up water unless it had been considerably softened during cooking, and from the point of view of preparing products that would rehydrate as desired, pressure cooking was found most satisfactory. Uniformly rapid rehydration of freeze-dried roast beef and pork has so far only been achieved when fat and connective tissue was removed before drying.

The freeze-dehydrated items of most promise were found to be: roast turkey white meat, roast chicken white meat, pressure cooked chicken and beef round steaks, all of which rehydrated rapidly and, when reconstituted, had a flavour typical of the fresh cooked meat, free from off-flavours. The beef product was similar to a braised steak. In practice, these products would be reconstituted with an appropriate gravy although the rate of rehydration of meat pieces was considerably reduced when the gravy was thickened, because the thickener restricts the rate of penetration by the liquid of the porous structure of the dried meat. Thickened gravies, however, could be used to reconstitute dehydrated ground beef either freeze-dried or hot-air dried.

Figures 2 and 3 show the appearance of combination dishes utilizing freeze-dried cooked items. Roast turkey slices (Figure 2) and rice can be rehydrated

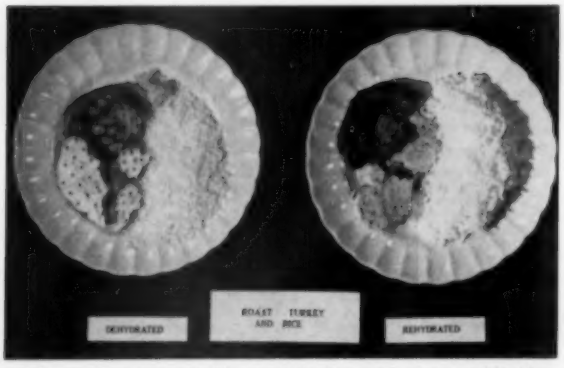

Figure 2. Freeze-dried roast turkey and rice combination. The two items can be rehydrated together.

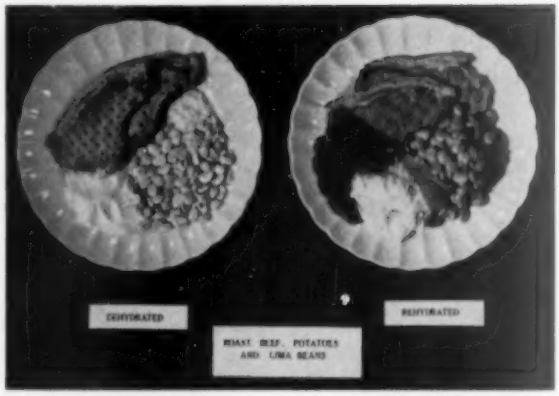

Figure 3. Freeze-dried roast beef, potatoes, and lima beans, a combination dish but the roast beef slices are rehydrated separately.

together. The roast beef slices (Figure 3) must be rehydrated separately from the potatoes and gravy. It will be noticed that the holes left by the spikes do not spoil the appearance of the reconstituted meat slices.

Hot-Air dried ground beef. The dark brown granules of hot-air dried ground beef containing about 25–30% fat and 4–6% moisture had a pleasant roast meat flavour and a crisp texture, when eaten dry. After rehydration by simmering for five minutes the product was slightly tough with a roast meat flavour. Prolonged simmering had little tenderizing effect (Table 2).

TABLE 2

Acceptability of dehydrated cooked ground beef

Method of drying	Simmering time (min.)	Average hedonic scale rating	Average 9-point scale ratings			Percentage rehydration
			Tenderness	Meat flavour	Juiciness	
Freeze	5	6.2	5.5	5.5	6.0	120
Hot Air	5	6.9	3.8	6.4	5.9	110
Hot Air	45	....	4.3	6.6	5.6	112

Analyses of dehydrated meats:
Freeze-dried; moisture, 1.0%; fat, 25.5%.
Hot Air dried; moisture, 5.6%; fat, 24.4%.

RATING SCALES

Tenderness	*Meat flavour*	*Juiciness*
1—Extremely tough	Extremely poor	Extremely dry
2—Very tough	Very poor	Very dry
3—Tough	Poor	Dry
4—Slightly tough	Below fair, above poor	Slightly dry
5—Not tender, not tough	Fair	Not juicy, not dry
6—Slightly tender	Below good, above fair	Slightly juicy
7—Tender	Good	Juicy
8—Very tender	Very good	Very juicy
9—Extremely tender	Excellent	Extremely juicy

A freeze-dried product prepared from the same batch of cooked meat as a standard of comparison, was pale brown in colour and had a mild beef flavour. It was too soft in texture to be pleasant when eaten dry. This product when reconstituted was slightly more tender than the air-dried meat but lacked the roast flavour (Table 2). An acceptance rating (Table 2) did not show a definite preference for one product or the other.

The minced meat as prepared for drying is capable of absorbing additional liquid than is added back in the gravy. As the rehydration figures for the dried product are expressed as a percentage of the initial water content it is not surprising that they exceed 100%.

Doty *et al. (4)*, from a survey of the literature, state that among other factors small particle size contributes to rapid drying and high rehydratability of the dehydrated product. As Sharp *(7)* points out, however, for uniform and rapid hot-air drying on trays it is necessary to maintain an open structure in the layer of meat. This is easily achieved if the meat is in the form of large granules about ½ in. in diameter but small particles cake and ball together forming a closely packed layer that dries slowly.

The degree of rehydration does not give an unequivocal indication of quality depending, as it does, on average particle size. The dried ground meat as normally prepared contains less than 5% of fine particles passing through a No. 10 sieve. When a sample was completely ground through a No. 10 sieve and rehydrated by simmering for 5 minutes the degree of rehydration was increased by 31% but the texture was slimy and unpleasant. As indicated in Table 2, using fresh samples of the same average granule size and also in other experiments using samples stored at elevated temperatures, it has not been found possible to correlate acceptability or juiciness with degree of rehydration.

An evaluation of air-dried ground beef as a "quick-serve" food for troops in forward areas was made by the Royal Canadian School of Infantry together with the Royal Canadian Armoured Corps School. Approximately 100 infantry men and 40 Armoured Corps personnel were required to use air-dried beef together with instant dehydrated potato for the preparation of one meal in the field, cooking individually and using those facilities normally available for mess tin cooking. The meat portion (dried beef, 1.5 oz.; flour 0.09 oz.; dehydrated onion 0.05 oz.) and dehydrated mashed potato (1 oz.) were packed separately under vacuum in small flexible plastic pouches and canned under nitrogen for transport and storage. The cans were opened and food distributed in the field. Printed instructions called for the addition of 6 oz. cold water to the meat and simmering for 5–10 minutes. Troops indicated their taste for the food (meat plus potato) on a 9-point hedonic scale. The ratings are summarized in Table 3.

The Royal Canadian Army Service Corps has also made a study of the suitability of air-dried ground beef in various large quantity recipes cooked in the mess kitchen.

TABLE 3

Acceptability of "quick serve" dried ground beef [1] and instant potatoes meal

Number of troops	Average hedonic scale rating
74	7.0
48	7.2
27	8.0

[1] Analysis of dried beef: moisture, 5.8%; fat, 22.2%.

The dish to be tested was served to 100 men. At the same meal the same dish prepared with fresh meat was served to 100 men plus any remaining diners. At each meal questionnaires were completed for both dishes and the consolidated responses are given in Table 4. Generally, except for the hamburg patties, the meat was favourably received. The product was not expected to be suitable for use in hamburg steak, but, as has been claimed before *(2)*, it may usefully replace raw ground beef in many dishes without loss of acceptability.

TABLE 4

Acceptability of dried ground beef in dishes cooked in static kitchen equipment

	Prepared from fresh meat			Prepared from dried meat [1]		
	Liked			Liked		
	As much as usual	More than usual	Less than usual	As much as usual	More than usual	Less than usual
	% of total	*% of total*	*% of total*	*% of total*	*% of total*	*% of total*
Shepherds pie	56	20	24	62	12	26
Hamburg patties	74	12	14	22	8	70
Meat loaf	64	10	26	58	10	32
Spaghetti and meat sauce	64	14	22	58	10	32
Beef croquettes	57	0	43	58	2	40

[1] Analysis of dried beef: moisture, 5.8%; fat, 22.2%.

If a good grade of beef is used, care taken to remove most of the connective tissue and the fat content maintained between 20 and 30%, it appears probable that hot-air dried ground beef would prove satisfactory as a substitute, in certain cases, for raw ground beef in mess cooking, as a "quick-serve" food suitable for military purposes, and also perhaps, for inclusion in such commercial products as "instant" soups. As the storage properties (which will be reported later) are satisfactory it would seem difficult to justify the application of the more complex and expensive vacuum freeze-drying process to this type of product. A study is in progress of the properties of hot-air dried cooked ground pork, chicken, and turkey, which may have similar value.

SUMMARY

Typical cooked meat items can be freeze-dried in about 4 hours using spiked heater plates to ensure efficient heat transfer during the dehydration process. Pressure cooked meats rehydrate rapidly but products cooked by dry heat rehydrate with more difficulty when fat and connective tissue is present.

Hot-air dried cooked ground beef is an acceptable item and rehydrates quickly. There appears to be little or no advantage in freeze-drying this type of product.

Acknowledgments

The following units of the Canadian Army collaborated in the acceptance trials:

The Royal Canadian Armoured Corps School.
The Royal Canadian School of Infantry.
The Royal Canadian Army Service Corps School.

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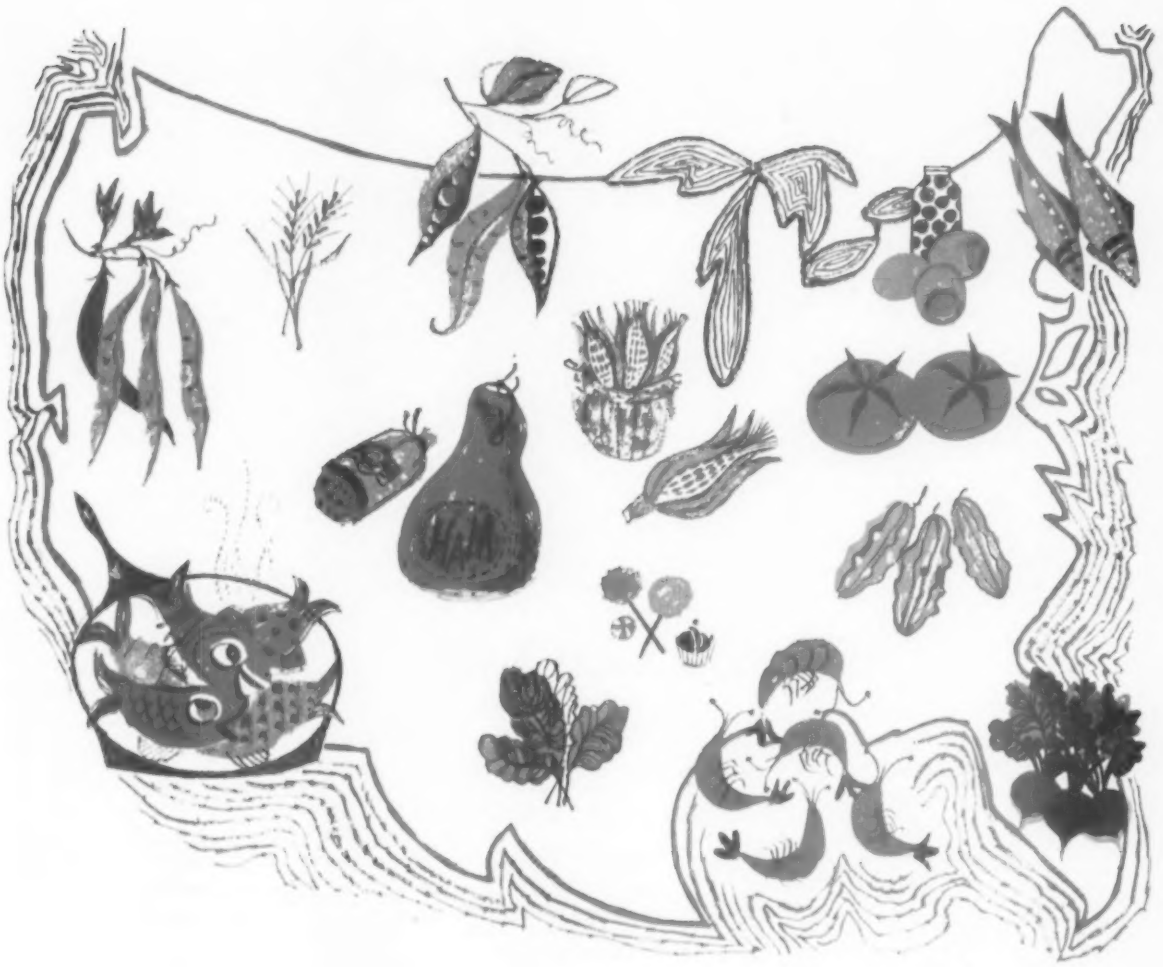

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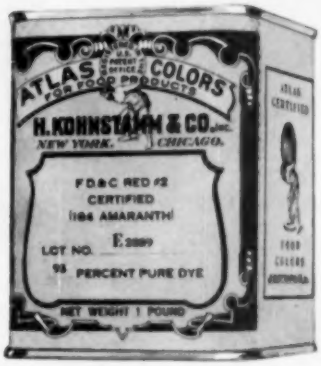

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On Color Measurements of Foods[a]

Angela C. Little, C. O. Chichester, and G. Mackinney

Department of Food Technology,
University of California,
Berkeley and Davis

(Manuscript received March 20, 1958)

IN INTERPRETING MEASUREMENTS of the color of foodstuffs, two assumptions are frequently made. They differ only in scope. The first is that by use of calibrated plaques, results can be translated to a common system, such as the C.I.E. color space for determining the absolute values and for such comparisons as one may wish to make with data from other laboratories. The second, more limited, asserts that while absolute values may differ, color differences between nearly matching colors will be valid for comparison of results between different laboratories. With measurements made on similar groups of samples, a given instrument might show a substantial displacement of co-ordinates relative to the C.I.E. and yet accurately preserve the relationship within a group of samples.

In "A Challenge to Colorimetry," Wright *(15)*, the problem is stated essentially as follows: On the trichromatic system of color measurement established by the C.I.E. a surface color can be specified by its chromaticity co-ordinates, (x and y) and its luminance. Whatever method is used to measure these quantities, including the photoelectric spectrophotometer, none is at present capable of specifying a color to a limit of accuracy that cannot be exceeded by the capacity of the eye to discriminate between two colors of nominally the same specifications, when compared side by side in a good light.

It is the purpose of this paper to test the validity of the above-mentioned assumptions, to show that results on different instruments cannot necessarily be translated directly to a common system, that the method of calculating perceptibility differences has an influence on conclusions derived from color-difference measurements made on different instruments, and finally that since regression analysis shows that a strongly positive relation exists between all instruments tested, a procedure can be set up for the separate calibration of each chromaticity co-ordinate and for tristimulus Y against an arbitrarily selected reference x, y and Y respectively, whereby sets of values may be transferred to a common system with much greater confidence.

EXPERIMENTAL

Materials. Twenty opaque[b] colored heavyweight papers (Bullseye Art Papers) with a matt surface were selected for measurement, in which the differences between upper and lower surfaces were essentially due to differences in luminance. The color gamut included 3 neutrals ranging from near white, to near black, and 17 samples of red, orange, yellow, green, blue and purple, with different degrees of saturation.

A set of 6 samples of Munsell color difference papers was also examined, together with a standard specified to be 5R/4/12 in the Munsell system. The papers differed metamerically with respect to the standard in hue ± and chroma ±, and non-metamerically in value ±.

Measurements were made with magnesium oxide, magnesium carbonate, vitrolite, vitreous glass and enamel plaques provided by the manufacturers. All calculations were made relative to magnesium oxide.

Finally two pureed baby foods, peas and carrots, were examined. Mixtures containing 5, 10 and 15% carrot by weight in pea puree were prepared to provide a series containing minor metameric differences.

Instruments. The following instruments were available in our laboratory: A Beckman DU (non-recording) Spectrophotometer with a reflectance attachment, a Gardner Automatic Color and Color Difference Meter, a Photovolt Tristimulus Photoelectric Colorimeter, and a Color Master Differential Colorimeter.

In addition, spectrophometric reflectance curves were obtained on certain samples from 3 different G. E. Recording Spectrophotometers and one Beckman DK-2 Recording Spectrophotometer.

Of the 3 G. E. Spectrophotometers, one was of the older type [Judd, Figure 22 *(8)*], two were of the later design (Figure 24). "In the former, the type of directional reflectance is perpendicular incidence and nearly diffuse viewing." With the other two, the light is incident at an angle of 6°, and the specular component may be introduced into the integrating sphere or excluded as desired. The Beckman DU instrument has no integrating sphere but relies upon a diffusing plate at 45°, with perpendicular incidence. The DK-2 has an integrating sphere of somewhat different design.

We are interested in the diffuse reflectance and, insofar as differences may exist in the effectiveness with which the specular component is excluded by the various instruments, differences may be anticipated in quantities calculated from the raw spectrophotometric data.

The photoelectric tristimulus colorimeters present a different problem because their light-filter-photocell combinations only approximate the C.I.E. reference standards. The three under examination rely on 45° reflectance with normal incidence.

Reference standards. For the Beckman DU Spectrophotometer, our working standard is cut from a magnesium carbonate block (McKesson & Robbins U.S.P.), purchased from a local drugstore and a smooth plane surface was obtained by buffing it by hand, face down, on a paper towel. A reproducible matt surface was thus obtained, which was calibrated against a freshly prepared magnesium oxide surface, with a polished metal backing, prepared in accordance with N.B.S. specifications *(9)*. Direct comparison of the two shows a crossover in the red, at about 560 mμ. We have been informed that this is due to the transparency of the oxide in the far red. If the oxide were deposited on carbonate or on some perfect reflector, this would not occur. In practice, the crossover has no bearing on the calculations, since the carbonate is our working standard. The factors applied for correction to the oxide surface are shown in Table 1.

Data from the other spectrophotometers were obtained by direct comparison with magnesium oxide, except for one where a vitrolite glass standard was used. This had previously been calibrated against the oxide by the Bureau of Standards, and the necessary corrections were applied.

Reference standards for the 3 filter photometers were plaques supplied by the manufacturers, calibrated by them.

[a] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, May 28, 1958.

[b] The reflectance characteristics were unaffected by the backing.

TABLE 1

Reflectance curves, $MgCO_3$ vs. MgO

λ	% R	Factor
400	91.0	0.91
420	91.5	0.915
440	92.0	0.92
460	94.0	0.94
480	96.0	0.96
500	98.0	0.98
520	99.0	0.99
540	100.0	1.00
550	100.0	1.00
560	101.0	1.00
580	102.0	1.00
600	102.0	1.00
620	102.0	1.00
640	103.0	1.00
660	103.0	1.00
680	104.0	1.00
700	104.0	1.00

Measurements. On the Bullseye Art papers, a total of 152 spectrophotometric reflectance curves were obtained, together with 240 separate measurements with the photoelectric filter colorimeters. The 4 surfaces of 2 samples of each colored paper were run on one G. E. Recording Spectrophotometer and on each of the 3 colorimeters.

The Munsell papers were run on two G. E. instruments, the Beckman DU and the Photovolt. The size of these samples precluded the use of the other colorimeters.

The pureed baby foods were run on the Beckman DU, the Photovolt, the Colormaster and the Gardner instruments.

All spectrophotometric data were converted to C.I.E. tristimulus values by the weighted ordinate method *(6)*.

RESULTS

It does not seem practicable to list *in extenso* the data on all samples. We therefore select two Art papers, a red with a dominant wave length of 617 mμ and a purity of 52%, and a yellow-green, 553 mμ and 34%, as representative. Results are shown in Tables 2 and 3. We next calculated perceptibility differences (ΔE), according to equations derived by the N.B.S. *(7)*, Scofield-Hunter *(12)*, Adams chromatic value *(11)*, and the graphical method of Davidson based on the MacAdam ellipsoid *(2, 3)*. The N.B.S. unit was redefined by Hunter *(7)*:

$$\Delta E = f_g \left[\left\{ 700 Y^{1.4} (\Delta a^2 + \Delta \beta^2)^{1/2} \right\}^2 + (k \Delta (Y^{1/2})^2)^2\right]^{1/2}$$

A k of 100 was used, and it was assumed that f_g, the gloss factor, was unity. The a, β transformations are given by Judd, page 253 *(8)*.

The Scofield-Hunter equation: $\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$ is based on the Hunter space transformation.

The Adams chromatic value is given by

$$\Delta E = 50 \left\{ (0.23 \Delta V_y)^2 + [\Delta (V_x - V_y)]^2 + [0.4 \Delta (V_z - V_y)]^2 \right\}^{1/2}$$

TABLE 2

Color data for a red λ 617 mμ, purity 52%

	Upper surface			Lower surface		
	x	y	Y	x	y	Y
G.E.-1						
a	.5093	.3162	13.40	.4837	.3143	16.70
b	.5077	.3172	13.59	.4828	.3145	16.78
G.E.-2	.4848	.3113	14.05	.4586	.3067	17.43
G.E.-3	.4993	.3182	13.79	.4731	.3135	16.83
Beckman DK-2	.5033	.3163	13.96	.4712	.3051	16.11
Beckman DU	.5084	.3131	13.37	.4821	.3104	16.78
Gardner						
a	.5119	.2944	11.95	.4830	.2964	16.30
b	.5240	.3008	11.90	.4823	.2967	16.40
Photovolt						
a	.5353	.3086	14.0	.5134	.3074	17.2
b	.5417	.3043	14.0	.5166	.3040	17.0
Colormaster						
a	.5054	.3234	10.75	.4929	.3209	12.45
b	.5027	.3235	11.0	.4916	.3207	12.68

TABLE 3

Color data for a green λ 553 mμ, purity 34%

	Upper surface			Lower surface		
	x	y	Y	x	y	Y
G.E.-1						
a	.3164	.4371	22.52	.3193	.4340	22.16
b	.3158	.4356	22.83	.3197	.4352	22.19
G.E.-2	.3215	.4278	24.99	.3255	.4298	24.32
G.E.-3	.3199	.4307	23.43	.3229	.4314	23.02
Beckman DK-2	.3159	.4292	23.57	.3247	.4302	23.71
Beckman DU	.3185	.4363	23.52	.3203	.4385	22.04
Gardner						
a	.3028	.4422	19.95	.3043	.4410	18.91
b	.3031	.4414	20.40	.3044	.4408	18.88
Photovolt						
a	.3136	.4317	22.0	.3136	.4317	22.0
b	.3114	.4373	22.8	.3103	.4337	22.0
Colormaster						
a	.3161	.4347	22.06	.3219	.4187	22.32
b	.3150	.4343	22.12	.3178	.4262	23.52

where 50 is the factor recommended by Judd *(8)*. The Munsell values V_x, V_y and V_z are obtained from the Tables A, B and C in the Appendix, Judd *(8)*.

The Davidson values are obtained directly from charts published by Davidson and Hanlon *(4)*.

The ΔE values are tabulated for the two specimens in Tables 4 and 5.

Discussion of the significance of the ΔE values listed in Tables 4 and 5 hinges upon the reliability of the data of Tables 2 and 3. The samples themselves were protected from light and dust and from smudges by careful handling and were checked at intervals for possible fading on the Beckman DU instrument. No changes were detected over a period of several months. The data in the preceding tables illustrate 4 (including upper and lower surfaces) of a total of 80 results.

TABLE 4

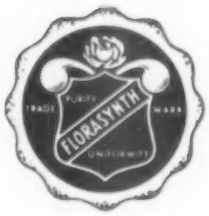
ΔE between upper and lower surface, for the red (Table 2) by various methods

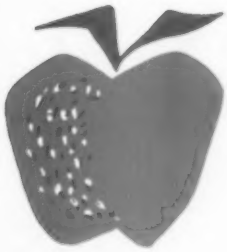
Method:	Scofield-Hunter	N.B.S.	Adams chromatic value	Davidson-Hanlon
G.E.-1				
a	4.31	11.33	5.90	13.6
b	4.17	10.65	5.79	12.8
G.E.-2	6.71	11.37	6.21	13.0
G.E.-3	4.08	10.91	6.09	12.6
Beckman DK-2	4.01	11.70	7.80	13.8
Beckman DU	4.51	11.47	6.16	13.6
Gardner				
a	5.82	14.99	8.63	18.4
b	5.98	17.76	9.15	21.4
Photovolt				
a	4.13	9.84	5.40	11.8
b	3.88	11.38	5.45	13.8
Colormaster				
a	2.66	5.06	3.44	6.9
b	2.71	4.50	3.37	6.2

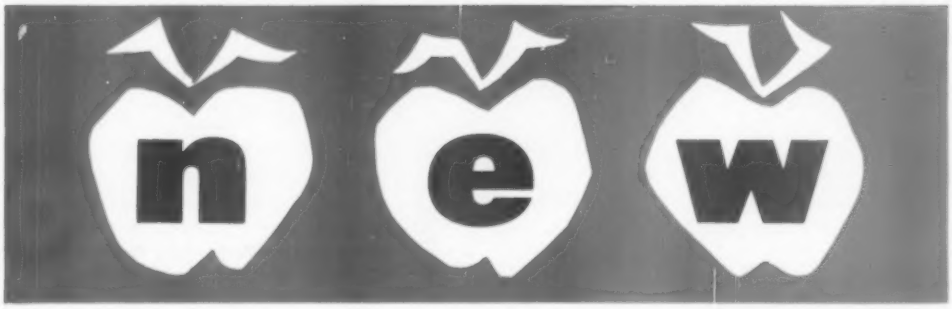
TABLE 5

ΔE between upper and lower surface, for the green (Table 3) by various methods

Method:	Scofield-Hunter	N.B.S.	Adams chromatic value	Davidson-Hanlon
G.E.-1				
a	1.25	2.28	1.94	2.6
b	1.30	2.18	1.88	2.5
G.E.-2	1.39	1.85	1.62	2.5
G.E.-3	0.88	1.29	1.17	1.9
Beckman DK-2	1.70	4.47	3.05	5.5
Beckman DU	1.73	1.71	1.93	2.0
Gardner				
a	1.67	1.53	2.08	1.6
b	2.21	2.05	2.61	2.1
Photovolt				
a	0	0	0	0
b	1.31	2.02	1.86	1.3
Colormaster				
a	3.61	7.53	6.27	7.1
b	1.84	4.00	2.84	4.2







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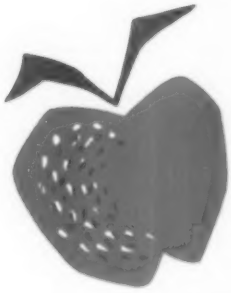

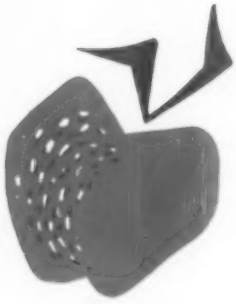

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We summarize in Table 6 the number of samples in which the deviations from the G.E. recording instrument selected as our reference, are less than 5% in ΔY, and in which $1/2(\Delta x + \Delta y)$ is less than 0.002 for the 3 photoelectric colorimeters. In addition, we include the number of samples in which the ΔE does not exceed 4 MacAdam units, as determined graphically by the Davidson method.

The maximum deviations for Δx or Δy, and in ΔE for these instruments are as follows: Gardner 0.025, 26; Colormaster 0.027, 18; Photovolt 0.03, 39; DK-2 0.01, 2.0.

This shows clearly that the photoelectric colorimeters can not be used directly to determine absolute color values. Furthermore, examination of Table 2 shows that deviations are to be found between different spectrophotometers which exceed the sensitivity of the eye and which may approach those of the colorimeters.

However, comparisons made vertically of the computed ΔE values, in Tables 4 and 5 suggest considerable reliability for any of the instruments used as a color difference meter.

We wish next to consider the relationship of the ΔE between the two surfaces for all the samples, computed by each of the 4 methods, for each colorimeter and the Beckman DK-2 against the G.E. reference. The correlation coefficients are given in Table 7. It may be agreed that any of the instruments may be used as a fairly reliable color-difference meter irrespective of the method. Examination of the raw data shows that the methods agree in predicting small color differences, particularly for highly unsaturated and near-neutral samples. However, as illustrated in Table 4, wide variations may occur, e.g. the 2.5-fold difference between the Scofield-Hunter and N.B.S. ΔE values. This means that conversion factors, such as those suggested, page 267, by Judd *(8)* will not be constants, applicable throughout the chromaticity diagram. This is of extreme importance in its application to color tolerances in foods.

TABLE 6

Number of samples with less than deviation stated below

Instrument	5% in ΔY	0.002 in Δx, Δy	$\Delta E < 4$
Gardner	36	7	9
Colormaster	34	13	23
Photovolt	79	10	30
Beckman DK-2[1]	34	17	30

[1] n = 38; for all others, n = 80.

TABLE 7

Correlation coefficients for ΔE, n = 80, vs. General Electric instrument

Method:	Scofield-Hunter	N.B.S.	Adams chromatic value	Davidson-Hanlon
Beckman DK-2[1]	.....	.....	0.897	0.810
Gardner	0.641	0.853	0.645	0.809
Photovolt	0.816	0.787	0.648	0.604
Colormaster	0.419	0.592	0.491	0.549

[1] n = 38.

Unlike the Art papers, with matt surfaces, and a low specular component, the Munsell papers had a high gloss. The C.I.E. quantities and ΔE values are shown in Tables 8 and 9 for the reference G.E. instrument, a second G.E. instrument, the Beckman DU, and the Photovolt.

It is seen that wide variation exists in the C.I.E. quantities measured on these samples with moderate metamerism and high gloss, but spatial relations between pairs are maintained, regardless of the instrument, with considerable reliability.

Regression analysis of data. If the respective x, y and Y values for each instrument for all the Art papers are plotted against the corresponding values for the selected G.E. reference data, linear plots are obtained, with relatively little scatter (see Figures 1, 2, 3 for the Gardner instrument.) G.E.-I was the only spectrophotometer on which all samples were run in duplicate. Precision was within 0.001 in x and y (see Table 10) and approximated the ability of the normal human eye to discriminate between minimal color differences. It was therefore chosen as our standard reference. In each case the abscissa (labeled p to avoid confusion with trichromatic x) refers to the G.E. values, the ordinate, q, to the other instrument. The slopes of the lines, the intercept, the standard deviations σqp, and σb of the slope itself, and the t value (student's distribution) are given in Table 10 *(14)*.

The correlation coefficient was in no case below 0.99. The uniformly high t values are significant beyond the 1% level.

TABLE 8

C.I.E. quantities determined for Munsell samples

	G.E. 1[1]			G.E. 2[1]			Beckman DU			Photovolt		
	x	y	Y	x	y	Y	x	y	Y	x	y	Y
5R4/12[2]	.5145	.3200	12.70	.4922	.3142	13.33	.5367	.3183	11.46	.5508	.3182	12.90
V+	.5121	.3193	13.55	.4885	.3130	14.16	.5324	.3172	12.23	.5540	.3103	13.50
V−	.5136	.3215	11.60	.4945	.3158	12.38	.5451	.3154	10.49	.5539	.3194	11.90
H+	.5262	.3262	12.98	.5115	.3223	13.46	.5486	.3241	11.53	.5661	.3183	13.00
H−	.4980	.3117	12.58	.4781	.3072	13.39	.5196	.3105	11.38	.5376	.3173	12.90
C+	.5222	.3195	12.42	.5015	.3155	13.31	.5434	.3188	11.24	.5645	.3161	12.50
C−	.5033	.3201	13.10	.4840	.3146	13.84	.5377	.3200	11.17	.5435	.3140	13.00

[1] Specular component excluded.
[2] According to the charts, this should read: x 0.5390, y 0.3125, Y 12.0.

TABLE 9

ΔE, Adams and Davidson values, for Munsell samples

Instrument Standard vs:	G.E. 1		G.E. 2		Beckman DU		Photovolt	
	Adams	Davidson	Adams	Davidson	Adams	Davidson	Adams	Davidson
1. V+	1.95	2.2	1.44	2.9	1.69	3.0	4.59	6.8
2. V−	3.10	2.6	2.26	2.0	1.91	6.8	2.47	2.4
3. H+	4.12	5.0	5.35	5.7	3.86	5.5	4.63	8.0
4. H−	4.99	6.9	4.23	6.0	5.30	6.8	3.91	7.7
5. C+	1.78	4.1	2.19	4.3	1.31	3.2	3.33	7.8
6. C−	2.64	5.8	2.01	4.5	1.05	2.7	2.46	3.4

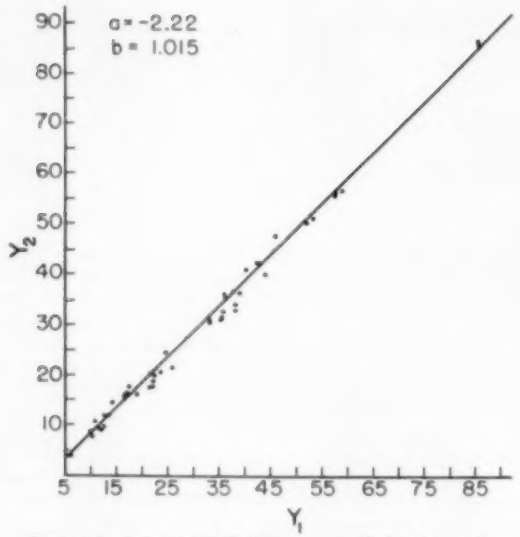


Figure 1. Luminance Y, Gardner vs. G. E. reference.

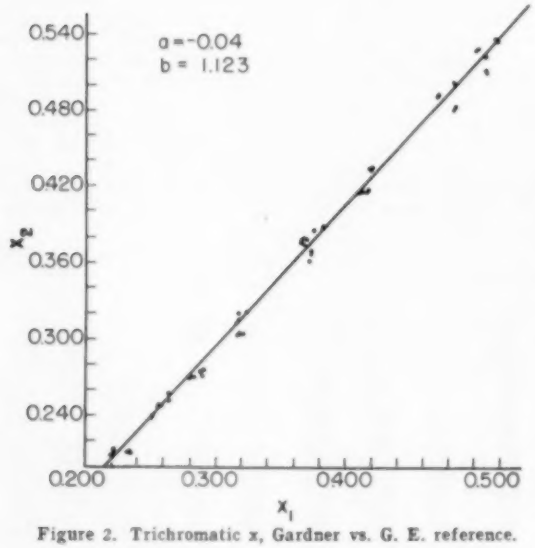


Figure 2. Trichromatic x, Gardner vs. G. E. reference.

TABLE 10
Instrument interrelations

Instrument		Slope (b)	Intercept (a)	σ_{qp}	σ_b	t
G.E.-1 vs. itself	x	1.0	origin	<0.001	.....	.....
	y	1.0	origin	<0.0007	.....	.....
	Y	1.0	origin	0.13	.....	.....
vs. G.E.-2	x[1]	0.90	+0.03	.....	.....	.....
	y[1]	0.99	−0.003	.....	.....	.....
	Y[1]	1.04	+1.2	.....	.....	.....
vs. Beckman DK-2	x	0.996	+0.003	0.005	0.011	90
	y	1.008	−0.004	0.003	0.009	115
	Y	1.020	−0.126	1.66	0.014	75
vs. Gardner	x	1.123	−0.04	0.008	0.011	105
	y	1.023	−0.009	0.009	0.016	66
	Y	1.015	−2.2	1.41	0.008	124
vs. Colormaster	x	1.003	−0.005	0.005	0.007	142
	y	1.125	−0.045	0.007	0.014	82
	Y	1.056	−2.6	2.59	0.015	71
vs. Photovolt	x	1.094	−0.028	0.007	0.009	120
	y	0.974	−0.010	0.007	0.014	70
	Y	0.975	+0.64	0.70	0.004	244

[1] Estimates (n = 14).

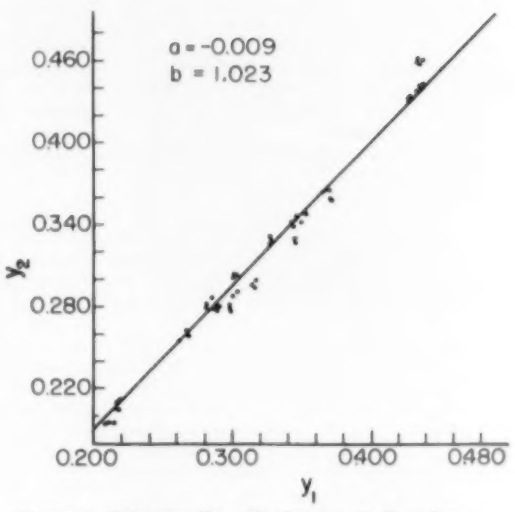


Figure 3. Trichromatic y, Gardner vs. G. E. reference.

In the final analysis, the color of a sample is specified by reference to three values, e.g.

$$\sum_{400}^{700} RE.\bar{x}\Delta\lambda, \quad \sum_{400}^{700} RE.\bar{y}\Delta\lambda, \text{ and } \sum_{400}^{700} RE.\bar{z}\Delta\lambda.$$

Spectrophotometric errors are confined to errors in measurement of R. The colorimeters approximate $\Sigma RE.\bar{x}$, etc. with varying degrees of success, compromises being made in filter-photocell-light source combinations and in the circuitry.

Despite the differences shown in absolute values between instruments, the regression analyses show constant relationships which in effect are measures of the constancy of the displacements of the quantities $\Sigma RE.\bar{x}$, etc. for a given instrument. Thus it should be possible to correct the results from a given instrument in terms of an arbitrarily selected reference instrument, and results should then agree within the standard deviation of the test instrument.

Application to food purees. Small metameric differences were achieved by the addition of 5, 10 and 15% carrot puree to pea puree, purchased on the local market. Within 3 hours of the time the can was opened, a small but consistent change

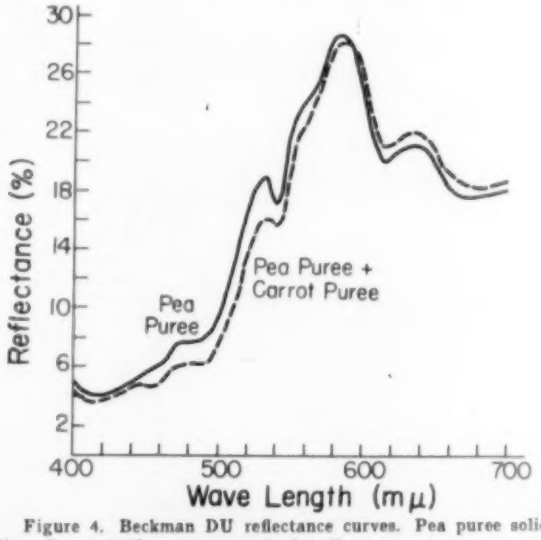


Figure 4. Beckman DU reflectance curves. Pea puree solid line. Pea + 15% carrot puree broken line.

was observed, for which a ΔE of 6.2 was calculated by Davidson's method. The change is shown first in a bleaching, an increase in Y from 20.5 to 21.9, succeeded by a yellowing, with a reversal in Y and significant changes in chromaticity. These may amount to 0.01 in x and y. It is essential therefore that comparisons be made under identical conditions.

The difference between pea puree alone and the puree with 15% carrot puree added is shown in Figure 4, where the reflectance curves were obtained on the Beckman DU Spectrophotometer. Results for the 3 tristimulus photoelectric colorimeters are shown in Table 11, together with corrections applied in accordance with the regression equations.

We then calculated ΔE by the Adams chromatic value and the Davidson-Hanlon methods, between successive mixtures. These are shown in Table 12.

TABLE 11

Analysis of purees

Sample		Gardner		Photovolt		Colormaster	
		1* Read	2* Corr.	1 Read	2 Corr.	1 Read	2 Corr.
Pea puree							
+ 0% carrot	Y	19.35	21.2	21.1	21.0	19.47	20.9
	x	.4065	.3994	.4035	.3944	.3973	.4011
	y	.4387	.4376	.4321	.4334	.4425	.4333
+ 5% carrot	Y	18.43	20.3	20.9	20.8	19.15	20.6
	x	.4198	.4112	.4112	.4015	.4043	.4081
	y	.4447	.4435	.4416	.4431	.4578	.4469
+ 10% carrot	Y	18.28	20.2	20.2	20.1	19.04	20.5
	x	.4293	.4197	.4270	.4159	.4132	.4170
	y	.4442	.4430	.4425	.4440	.4617	.4507
+ 15% carrot	Y	18.10	20.0	20.1	19.9	18.94	20.4
	x	.4339	.4238	.4298	.4185	.4185	.4222
	y	.4449	.4437	.4448	.4464	.4611	.4499

* Column 1, calculated from raw data.
* Column 2, calculated from regression analyses.

TABLE 12

Color differences in purees (on corrected basis)

	Adams ΔE			Davidson-Hanlon ΔE		
	Gardner	Photovolt	Colormaster	Gardner	Photovolt	Colormaster
2–1*	4.0	3.4	5.0	7.0	4.3	5.0
3–2	3.1	4.7	3.1	6.6	9.7	5.3
4–3	1.5	4.2	1.6	3.1	1.7	3.9

* Color differences between pea (1) and pea plus 5% carrot (2), plus 10% (3), etc.

DISCUSSION

The samples used for instrument comparison—namely, the sheets of heavy Art paper with opaque matt surfaces—were chosen for these reasons: they were inexpensive, readily available in a wide variety of colors; the surfaces showed no significant variation over the entire area in the diffuse reflectance, measured spectrophotometrically; protected from light and dust, they showed no differences when measured a year later; the two surfaces of each paper differed sufficiently in total reflectance for ΔE evaluations; unlike food samples which changed with time and were less homogeneous, the papers could be sent to other laboratories without difficulty; finally plaques could readily be cut to the size needed for any given instrument.

Values of x, y and Y ranged from 0.220 to 0.520, 0.200 to 0.460, and 5 to 85%, respectively. Excitation purities ranged from 5 to 65%, a range which should cover the majority of foods. However, results must be interpreted within this framework, without extrapolation to highly saturated colors as yet.

The results obtained from 5 spectrophotometers and 3 tristimulus photoelectric colorimeters on these samples clearly indicate the fallacy of the assumption that raw data can be directly translated to a common system for comparison of absolute values. Inspection of Tables 2 and 3 shows that not only do the filter photometers substantially displace the co-ordinates, but that similar discrepancies may be found between spectrophotometers, even those of the same design.

The more limited assumption that color differences between nearly matching colors will be maintained, is partially validated by the data of Tables 4 and 5. As between spectrophotometers, the ΔE values show satisfactory consistency for a given method of calculation. This is somewhat less evident for the colorimeters. The correlation coefficients (Table 7) are positive and significant. They indicate that any instrument may be used as a fairly reliable measure of color difference, but we have no assurance, for any randomly selected pair of samples, that the ΔE values for two or more instruments will be acceptably close.

We have limited data on seven Munsell papers with high gloss. The dimensions of the samples precluded measurement on two of the colorimeters without reducing the area of the illuminated field. We have not included these data in our subsequent regression analyses because the excellent absolute agreement between the Beckman DU and the reference G.E. instrument with matt surfaces no longer pertains to those with high gloss; the deviation between Photovolt and G.E. is also larger than that found in the comparison of the matt surfaces. We may surmize that regression lines will show different displacement relative to the standard for glossy and matt surfaces. We have therefore left the problem of high gloss surfaces for later consideration.

We have used four methods for calculating ΔE. The Scofield-Hunter equation gives equal weight to all 3 attributes. The Davidson-Hanlon method emphasizes chromaticity in these samples because of the relatively small differences in Y. The N.B.S. unit weights the Y in terms of the chromaticity difference. The Adams chromatic value equation incorporates the Munsell value function into each attribute. Insofar as small color differences in foods (particularly when processed) depend on differences in lightness, it seems reasonable that the N.B.S. unit and the Adams chromatic value will give the most realistic evaluation of foods. This applies primarily to minor differences caused by processing or storage, not to major metameric differences such as those involved in the ripening of fruit.

A linear relation was demonstrated between the x, y and Y functions determined respectively on a given instrument and on the selected reference spectrophotometer. Each function could consequently be corrected, and results thereby placed on a comparable basis, within the standard deviation of the measurement on the given instrument. The deviation may, in a given case, exceed the minimum subjective perceptibility difference. The question is not yet answered as to whether the precision with which the color of a food can be measured instrumentally falls

within an acceptable color tolerance for that food. As shown in Table 10, the slopes of the regression lines for the various instruments deviate significantly from unity, and the lines do not pass through the origin. These lines are unique for the instruments studied, and any other instrument must be similarly calibrated by use of a number of appropriate plaques. Federal Standard Colors No. 595 *(5)* might well be used in this connection.

To increase the sensitivity of the method for applying corrections, the regression lines could be calculated from a statistically adequate number of calibrated plaques limited to a color range within which a series of samples might be expected to fall. Additional refinement should be attainable by use of all 3 tristimulus values (XYZ) rather than x, y and Y, since x and y are also affected by errors in determining Y and Z, and X and Z, respectively. It remains to be determined whether this would bring instrumental precision within acceptable tolerances.

What has hitherto been attempted is the measurement of color differences by reference to an imprecise system of co-ordinates. This is illustrated in Figure 5. The true plot of colors P, Q, R, S is distorted to P_A——S_A and P_B——S_B for the two instruments A and B. With three degrees of freedom, the color differences measured by the quantities $P_A - Q_A$ and $P_B - Q_B$ cannot be equated without individual corrections applied to the respective ordinates.

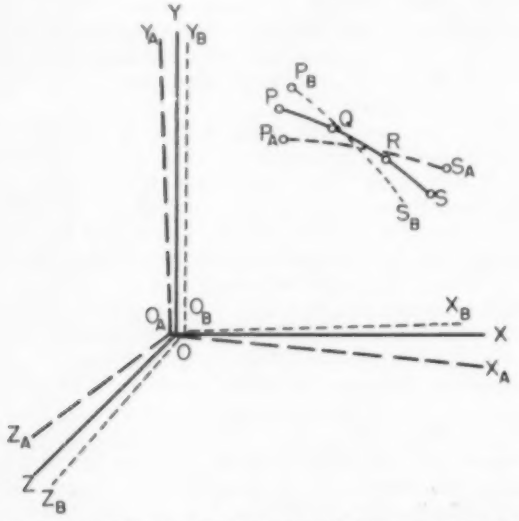


Figure 5. Schematic plots of color differences. Note: Loci distorted by displacement of C.I.E. co-ordinates by hypothetical instruments A and B.

So long as these linear relations can be established, the objections raised to the use of photoelectric colorimeters, e.g. Bouma, p. 158, *(1)*, Judd, p. 162 *(8)*, which stress filters, or filter-photocell-light source combinations, lose validity. The problem is rather one of instrument precision, not its ability to specify a color directly.

We have applied the procedure to a series of vegetable purees, Tables 11 and 12, and the corrected values fall within the standard deviation of estimate. Refinements in the computation of corrections or increases in instrument sensitivity could further reduce the discrepanies in ΔE (Table 12), and any instrument could then be used with equal confidence in measuring color or color differences.

We have been interested in the comments of Shipley and Walker *(13)* on raw data presented by MacDonald and Bentley *(10)*. The latter made a detailed comparison of G. E. Spectrophotometers and Color Eye Colorimeters, measuring the reflectance characteristics of 3 series of tiles (red, blue and green) with very low Y values. Shipley and Walker calculate that out of 66 measurements only 13 standard deviations were as low as 0.002. "This means that the precision in 53 cases, over 4 physical models, was not as good as that in the normal human eye." The 4 physical models referred to are spectrophotometers.

We have therefore applied our procedure to the raw data in Table 2 of MacDonald and Bentley. We find linearity between instruments with respect to Y. For instruments A vs. B, vs. D, vs. E, we estimate intercepts and slopes as follows: 0, 1.0; −0.17, 1.05; −0.1, 1.01. Only in instrument D is there appreciable scatter below a Y value of 1.0%.

In the case of trichromatic coefficient y, linearity is still found, although the scatter is greater. Trichromatic x values however show no evidence of linearity. Spectrophotometer A was unable to distinguish trichromatic x differences between the blue and green tiles. This was not the case with the other three spectrophotometers, nor with the Color Eye Colorimeters. Two factors limit the definition of such a relationship in their study. Sampling is limited to three sharply localized areas in the color space, and instrumental precision may be poor at these low reflectance values. However, with the exception of instrument A in measuring trichromatic x, the indications are that linear relationships exist.

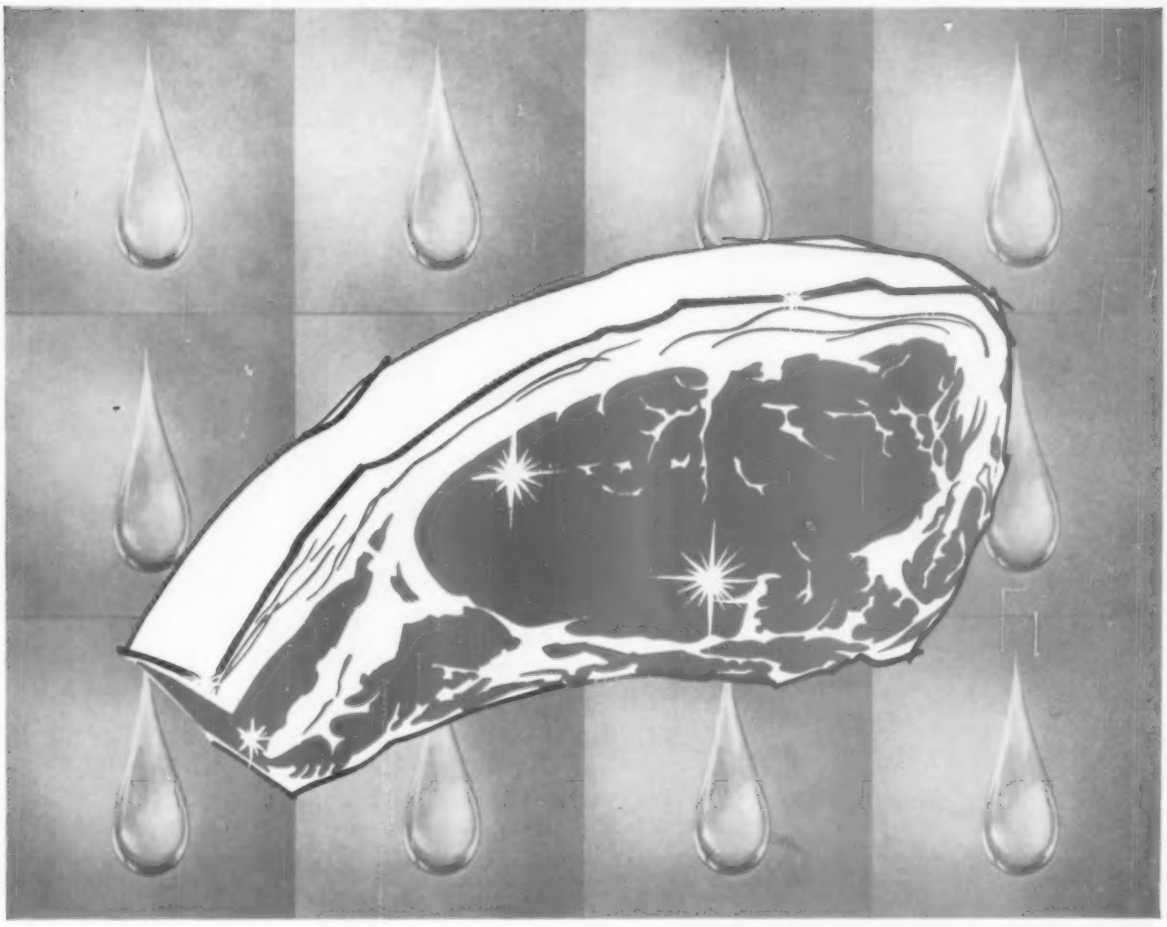
SUMMARY

By applying statistical methods to the results obtained with a series of colored papers on a number of instruments, including five spectrophotometers and three tristimulus photoelectric colorimeters, we have obtained highly significant linear relations between all instruments studied. Regression equations were calculated for each attribute of color for each instrument against an arbitrarily chosen reference spectrophotometer.

In this way, results from a series of vegetable purees whose reflectance characteristics were measured on three different makes of colorimeter were placed on a comparable basis and agreement was obtained within the standard deviation.

Acknowledgments

We are especially indebted to Dr. Henry Hemmendinger of Davidson and Hemmendinger, Easton, Pennsylvania for his generous co-operation in the project; to Professor D. Finch,



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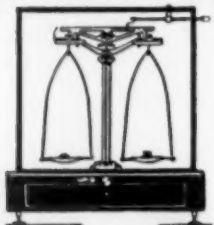

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The Effects of Dehydration on Actomyosin in Fish and Beef Muscle

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PRESERVING FOOD BY DRYING is a very ancient process. The traditional dried foods developed characteristic textures and flavours during drying, however, and were acceptable only to consumers who had acquired a taste for them. Since modern dehydrated foods must compete with their fresh counterparts, changes in flavour and texture should be kept to a minimum. These changes may result in part from protein denaturation and enzymic action during drying and storage; therefore the behaviour of proteins and enzymes under these conditions is of great interest.

During dehydration some portions of the foodstuff will dry more quickly than others and (except where dielectric heating is used) the wet areas will remain at a lower temperature than the dry, due to evaporative cooling. Proteins are known to be more thermostable when dry than when hydrated *(2, 19)*, and so it is probable that a proportion of them at least will not be damaged by dehydration.

If vegetables are dried by hot air methods without preliminary scalding to denature the proteins, the enzymes will remain active and the material will become tough and discolour badly during drying *(3)*. These dried vegetables appear to store less well than those which have first been scalded, though definite evidence on this point is lacking *(25)*.

Meat and fish have usually been dried after cooking since hot air methods would not dry the raw tissues satisfactorily. In recent years, however, there have been many successful attempts to freeze-dry raw meats though generally on a small scale *(8, 17)*.

At the Experimental Factory freeze-drying is carried out on a commercial scale. The process used is known as vacuum contact-plate drying (VCD) and has already been described *(15, 16, 18, 35)*. In this process, frozen steaks etc. of fish or meat are placed on aluminum trays covered with lids, which are loaded between horizontal heating plates. The plates, which can be moved together to ensure good thermal contact with the material to be dried, are contained in a steel chamber. This chamber can be evacuated to low pressure. In recent modifications of the process *(35)*, the material is freeze-dried for the first few hours, and the internal temperature is allowed to rise above freezing point only when the outer layers of material have been dried. Again the moist tissue remains cool, and complete denaturation of enzymes and other proteins is very unlikely.

Before muscle tissue is used for food the actin and myosin have combined to form actomyosin, which is present in greater quantity than any other protein *(1)*. Actomyosin, therefore, is of particular interest. It is rather labile, so its survival of any particular treatment means that many other proteins and enzymes will also remain undamaged.

Actomyosin is itself an enzyme for it can hydrolyse adenosine triphosphate (ATP) to adenosine diphosphate (ADP) and inorganic phosphate. Denaturation of actomyosin can therefore be followed by measuring the adenosine triphosphatase (ATPase) activity. Other properties of actomyosin which are lost on denaturation, are solubility in 0.5M potassium or sodium chloride solutions, and contraction in the presence of ATP. These too may be used to follow denaturation. A brief preliminary report of this work has already been made *(21)*.

MATERIALS AND METHODS

All the water used in these experiments had been distilled once in glass apparatus. Diethylbarbiturate buffer (veronal) was prepared according to Michaelis *(27)*. 2-Amino-2-hydroxymethylpropane-1: 3-diol buffer (tris) was made up as described by Gomori *(14)*. Adenosine triphosphate and adenosine diphosphate solutions were prepared from the crystalline disodium salt and the sodium salt (Sigma), respectively, and adjusted to the required pH.

Moisture determination. The moisture in fresh or reconstituted material was determined by mixing a weighed, ground sample with sand and heating on a water bath at 100° C. for 1 hour, with occasional stirring to prevent caking. The material was then dried to constant weight in an oven at 100° C.; about 4 hours were usually required.

The moisture in dehydrated material was determined by drying a ground sample in a vacuum oven at 70° C. for 5 hours.

Fat determination. Fat content of fresh, dehydrated, and reconstituted material was determined by a modification of the Gerber method for milk and cheese analysis.

Tissue suspensions. These were prepared by maceration of a known weight of tissue in an all-glass macerator (Townsend and Mercer) which consisted of a stationary pestle fitting into a rotating glass tube. The apparatus was chilled to 0° C. before use. The beef studied throughout was round steak and the fish, cod fillet *(Gadus callarias)*. The tissue was macerated to a uniform paste with a few ml. of water; 40–50 ml. water were added and the suspension was filtered through a single thickness of gauze to remove any connective tissue. If necessary the suspension was centrifuged (800 g. for about 5 minutes) and the insoluble portion was washed by suspending it in water and recentrifuging. The residue was carefully resuspended in water and made up to a definite volume.

Catalase determination *(5)*. An enzyme suspension in 0.01M phosphate buffer (pH 7.0) was added in varying amounts to 2 ml. samples of 0.4% hydrogen peroxide. Samples were withdrawn after 1 and 2 minutes and residual peroxide was titrated with potassium permanganate. The velocity of the reaction was proportional to the activity of the catalase present (mg. H_2O_2 decomposed/min./mg. dry weight).

Adenosine triphosphatase (ATPase) determination. The method used was a modification of that of DuBois and Potter *(10)*. The determination was carried out in 15 ml. centrifuge

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tubes, shaken in turn by hand during incubation at 25° C. or 37° C. The reaction was stopped by the addition of 0.85 ml. of 10% trichloracetic acid. The tubes were centrifuged and 0.5 ml. samples of the supernatant liquid were taken for phosphate analysis by Long's modifications *(26)* of the method of Berenblum and Chain *(4)*. After the development of colour, the isobutanol extracts were suitably diluted and the absorption was read against a reagent blank either in an S.P. 400 colorimeter (Unicam) at 680 mμ, or where stated, in a Spekker (Hilger and Watts) using filter 608 and a 1 cm. cell. ATP and enzyme blanks were then subtracted. Phosphate standards, which were sometimes used, were prepared from KH_2Po_4 and contained 3 to 10 μg. phosphorus per tube. Where necessary the enzyme activities are expressed in terms of μg. phosphorus produced/min./mg. non fatty solids (NFS).

EXPERIMENTS AND RESULTS

Preliminary experiments were carried out to test whether enzymes, and hence proteins, could survive dehydration by the VCD process. For these, catalase was selected since its activity is fairly easily determined by estimating the peroxide remaining after given periods of time with permanganate titrations. The amount of catalase in muscle tissue was too small to be determined quantitatively. A quantitative estimation of the activity before and after dehydration was made on raw ox kidney, which has a higher catalase activity. Results show that about 60% of the catalase activity survived dehydration.

Adenosine triphosphatase. Behaviour of actomyosin ATPase in muscle fibrils can be modified by various methods of washing and extracting the fibrils *(31)*. Suitable procedures for the determination of ATPase were therefore developed for the type of enzyme preparation actually used in this study. These preparations were made from fresh beef which had passed into rigor.

Solubility of ATPase. A macerate of 1 g. raw, lean beef was made up to 100 ml. with water and held at 0° C. One portion was set aside (a). Another 10 ml. portion was centrifuged in chilled cups (800 g. for 10 min.); the supernatant was retained (b). The precipitate was washed with 10 ml. water, centrifuged again and the supernatant discarded. The precipitate was suspended in 10 ml. water (c). The ATPase was determined in the complete muscle suspension (a), the water-soluble extract (b) and the washed, water-insoluble fraction (c) (Table 1). There was appreciable activity in (a), somewhat less in (c) and scarcely any in (b). Repetition of this experiment gave similar results, save that the activity of the water-soluble fraction was sometimes higher, though never more than a few per cent of that of the other fractions.

Other enzymes present in extracts. For this experiment a beef suspension was made in water and centrifuging and washing were carried out as before on three 10 ml. portions. Suspension of the washed macerate in water, in original water soluble extract and in boiled extract showed that the activity was about the same in water or the boiled extract. Presence of a heat-labile factor which increased the rate of phosphate production was demonstrated by the greater activity of the macerate in the unboiled extract. The problem was not investigated further since actomyosin-ATPase is not water soluble.

From an examination of the action of the washed macerate on ADP it was established that there is no myokinase or general apyrase present.

TABLE 1

Solubility of ATPase[1]

Fraction	Optical density
(a) whole homogenate	0.271
(b) water-soluble fraction	0.002
(c) water-insoluble fraction	0.203

[1] Each tube contained $CaCl_2$ (3×10^{-3}M), barbiturate buffer (1.2×10^{-2}M, pH 7.4), ATP (3×10^{-3}M), and water to a final volume of 0.65 ml. In addition tubes 1, 2 and 3 contained 0.2 ml. of whole muscle suspension, washed muscle suspension and aqueous muscle extract respectively. Blanks were set up for each muscle fraction and for the ATP. The temperature of the incubation bath was set at 37° C. Other conditions are as detailed in the section on methods.

TABLE 2

Optimal concentration of calcium ions[1]

Ca^{++} (M x 10^3)	Optical density
1.2	0.064
2.1	0.126
4.9	0.138
6.1	0.136
9.2	0.138

[1] Each tube contained veronal buffer (1.2×10^{-2}M, pH 7.4), ATP (3×10^{-3}M), 0.1 ml. of washed beef macerate (0.5 g. beef/100 ml.), and water to a final volume of 0.65 ml. Enzyme and ATP blanks were also prepared. Temperature of bath 37° C. Optical densities were read in a Spekker.

Effects of calcium and magnesium ions. A test was carried out to find what concentration of calcium ions was required for maximum activity of the ATPase (Table 2). This concentration was found to be about 5×10^{-3}M.

Both calcium and magnesium have been used in the past to activate actomyosin-ATPase, so the effects of these ions were measured separately and together at pH 7.4 (Table 3). There was no difference in their activity at a concentration of 6×10^{-3}M. When present together their combined effect was a little less than that of each separately.

Effect of buffer. To enable tests of the effects of pH to be made, it was desirable to work with a buffer (e.g. tris) which has a higher pH-range than veronal. To ensure that tris had no specific effects on the system, the ATPase activity was measured in each buffer at pH 7.4 (Table 4). The enzyme was very slightly more active in tris, but the effect is small and may even be due to the increased ionic strength.

Effect of pH. Slight variations in pH can cause marked differences in the activity of an enzyme within certain ranges of its pH-activity curve. To avoid such variations and to ensure that the enzyme was working at a pH not far removed from its optimum, the pH-activity curve was determined over the range 7.2 to 9.2 in tris buffer, with two different enzyme preparations (Figure 1). The activity increased only very slightly with increasing pH but no optimum was found within this range. In some unpublished experiments it was observed that within the range of ionic strength found in the system used to determine ATPase, decreasing ionic strength slightly diminishes the ATPase activity. The ionic strength of the buffer decreases as its pH increases; therefore the actual increase in activity with pH was slightly greater than the observed rise, though the pH-activity curve was still fairly flat. Thus any pH in the range 7.2 to 9.2 would be suitable for the ATPase determination. Tris buffer has its maximum buffering power at pH 8.14 and so this pH was selected for the estimation of ATPase.

On the basis of this preliminary work suitable conditions were established for the determination of ATPase such that the amount of inorganic phosphorus produced was proportional to the activity of the enzyme present. The system consisted of tris buffer (2.3×10^{-2}M, pH 8.14), $CaCl_2$ (6×10^{-3}M), ATP (6×10^{-3}M), 0.05 to 0.20 ml. of a washed enzyme preparation made from macerated, lean, raw beef or fish muscle, and water to 0.65 ml.

TABLE 3

Effect of calcium and magnesium on ATPase activity[1]

Enzyme suspension (ml.)	Ions used	Optical density
0.1	Ca^{++}	0.117
0.2	Ca^{++}	0.232
0.1	Mg^{++}	0.114
0.2	Mg^{++}	0.242
0.1	Ca^{++} and Mg^{++}	0.096
0.2	Ca^{++} and Mg^{++}	0.211

[1] Each tube contained veronal buffer (1.2×10^{-2}M, pH 7.4), ATP (3×10^{-3}M), washed beef macerate (0.5 g. beef/100 ml.), $Mg\ Cl_2$ and/or $CaCl_2$ (each 6×10^{-3}M). Temperature 37° C.

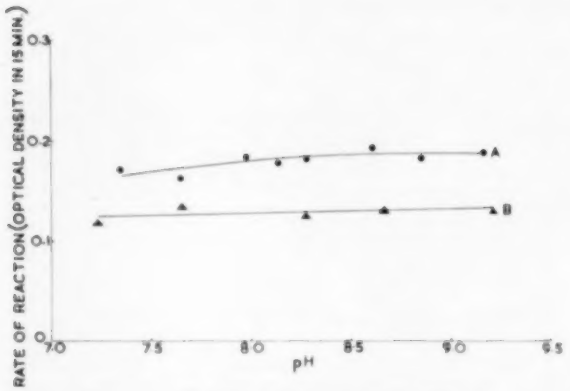

Figure 1. The pH-activity curve for ATPase.

Each tube contained $CaCl_2$ (6×10^{-3}M), ATP (6×10^{-3}M), tris buffer (2.3×10^{-2}M), 0.15 ml. washed beef macerate (0.5 g./100 ml.) and water to a final volume of 0.65 ml. The pH varied from 7.2 to 9.2. Temperature of incubation 25° C. Curves A and B are for beef from different animals. The activities are given in arbitrary units—the optical densities of the solutions resulting from phosphate determinations.

ATPase in raw beef fresh and dehydrated. These determinations were carried out on adjacent slices of round of beef, one of which had been dried by the modified VCD process *(35)* and one of which was undried. The slices were trimmed free of visible fat and minced. From the well-minced samples, portions were taken for ATPase, fat and moisture determination. The activities were determined on 0.05, 0.10, 0.15 and 0.2 ml. portions of beef suspension, and the average activity in μg. inorganic phosphorus liberated per mg. of NFS per min. was found graphically. The results are given in Table 5.

TABLE 4

Comparison of the effects of veronal and tris buffer on ATPase[1]

Volume of enzyme suspension (ml.)	Buffer	Optical density
0.1	veronal	0.277
0.2	veronal	0.478
0.1	tris	0.281
0.2	tris	0.498

[1] Each tube contained $CaCl_2$ (6×10^{-3}M), ATP (3×10^{-3}M), washed beef macerate (0.5 g./50 ml.), water to a final volume of 0.65 ml. and either veronal buffer (1.2×10^{-2}M, pH 7.4) or tris buffer (2.3×10^{-2}M, pH 7.4).
Enzyme and ATP blanks were also prepared.

TABLE 5

ATPase in beef before and after dehydration[1]

	Activity (μg./P/mg. N.F.S./min.)	% Activity remaining
Fresh	2.6	42
Dehydrated	1.1	
Fresh	3.4	56
Dehydrated	1.9	
Fresh	2.0	50
Dehydrated	1.0	
Fresh	3.8	79
Dehydrated	3.0	
Fresh	2.6	62
Dehydrated	1.6	

[1] The standard conditions given in the text were used for ATPase determination. The enzyme preparation was made from 0.5 g. fresh or 0.3 g. lean, dried beef, macerated, washed and made up to 100 mls. The activity in μg./P/mg.NFS/min. was found graphically by comparison with phosphate standards.

They show that the dehydrated material retains more than half the ATPase activity of the fresh. These determinations were carried out on material dried in consecutive experiments in a small-scale plant. When determinations were carried out intermittently on material dried on a commercial-scale plant, results were similar though the amount of activity remaining after dehydration was rather more variable (30 to 85%).

ATPase in fresh and dehydrated fish. The amount of ATPase in fish was estimated by the same method before and after dehydration. Enzyme preparations were made from muscle fibres dissected free of myosepta *(22)*. The sample was macerated, washed, and made to volume, except that it was not filtered through gauze, as for beef. This was partly because there was very little connective tissue left after removal of the myosepta and partly because the macerate was sticky and tended to remain on the gauze. This stickiness made the suspension difficult to disperse and hence difficult to pipette accurately. Graphs of activity against dry weight of fish used, showed more scatter than those for beef. It is quite clear however that a similar percentage of the ATPase did survive dehydration (Table 6).

TABLE 6

ATPase in fish before and after dehydration[1]

	Activity (μg.P/mg. dry weight/min.)	% Activity remaining
Fresh	4.6	54
Dehydrated	2.5	
Fresh	4.8	75
Dehydrated	3.6	
Fresh	4.6	58
Dehydrated	2.8	

[1] The standard conditions as given in the text were used for ATPase assay. The enzyme preparation consisted of 1.0 g. fresh or 0.3 g. dehydrated cod muscle fibres, free of myosepta, macerated, washed and made up to 100 ml. Determinations were carried out on 0.05, 0.10 and 0.15 ml. portions and the average rate in μg.P/mg. dry weight/min. was found graphically by comparison with phosphate standards.

SOLUBILITY MEASUREMENTS

Actomyosin can be extracted from fresh muscle with strong (>0.5M) salt solution. This method has already been used to study denaturation in fish *(12, 22, 29)*. Since cod muscle contains very little fat and it is possible to obtain relatively large amounts of the muscle fibres almost free of connective tissue, studies of solubility before and after dehydration were made on these rather than on beef.

Muscle fibres were chopped by hand and extracted with either phosphate buffer (0.5M KCl/0.02M phosphate buffer, pH 7.0) or buffered salt solution (5% NaCl/0.02M $NaHCO_3$, pH 7.4). Extraction was carried out in an Atomix Blender which had a close-fitting perspex baffle to prevent foaming. Blending was done either at full-speed for 60 seconds or at half speed for 30 seconds, followed in the latter case by storage of the suspension overnight at 0° C. Suspensions were centrifuged or filtered and the nitrogen content of the resulting solutions was determined by Kjeldahl analysis. Non-protein nitrogen was determined on filtrates of solutions treated with trichloracetic acid, and protein nitrogen was obtained as the difference.

Initial experiments were carried out on fresh cod to test the methods. Results showed that 85–90% of the total protein nitrogen could be extracted by either of the above methods using either extracting solution. These values were obtained on the supernatants after the extracts had been centrifuged at 800 g. for 15–30 minutes in the cold. They could be reduced to about 50% for the NaCl and 30% for the KCl extracts, by filtering through paper (Whatman No. 42). In addition, when the extracts made by high speed blending were centrifuged at increasing speeds (centrifugal force up to 1,000 g.), the amount of soluble protein found decreased sharply, as the centrifugal force increased. Extracts made by half-speed blending and overnight extraction did not show this latter effect appreciably.

The solubility of dehydrated fish in the NaCl solution was examined in the same way. Extracts made by blending at half-speed and leaving the suspension at 0° C. overnight contained only about 30% of the total protein nitrogen. The apparent solubility of the protein could be increased greatly by blending at full speed but it was reduced again to about 30% by high-speed centrifuging or by filtering. If either fresh or dehydrated fish were blended in an Atomix at full-speed, results for the solubility of the proteins were not reproducible. Half-speed blending followed by centrifuging which gave satisfactory results with fresh fish seemed to show that virtually all the actomyosin in dehydrated fish was denatured, since sarcoplasmic proteins amount to approximately 30% of the soluble protein *(1)*. This appeared to contradict results found by determinations of residual ATPase activity.

CONTRACTILITY OF DRIED MUSCLE FIBRES AFTER RECONSTITUTION

Contractility of muscle fibres is due to their actomyosin content. Denaturation of the actomyosin should abolish this reaction. Although the ATPase can be activated by either calcium or magnesium, contraction will only take place in presence of magnesium, which was therefore used in these experiments.

For preliminary tests the fibres were dried on a laboratory scale. Strips of muscle about 1 x 1 x 10 mm. were laid on microscope slides and covered with a few drops of water. The slides were put into a refrigerator at −20° C. until the water froze solid. They were then placed in a vacuum desiccator over sulphuric acid. Vacuum was drawn and the evacuating pump was kept running until the fibres were dry. This took about 1.5 to 2 hours. The dry strips of muscle were split into smaller bundles and rehydrated in veronal buffer (1.2×10^{-2}M, pH 7.3) containing $MgCl_2$ (6×10^{-3}M). Single fibres were dissected out with fine needles under the x30 power of a stereoscopic microscope. Individual fibres were observed under this microscope while a drop of ATP (2.6×10^{-3}M) was added.

Fibres from round of beef in rigor were examined. Both fresh and dried, reconstituted fibres contracted as soon as the ATP reached them. Reconstituted fibres contracted to a lesser extent than fresh and at a slightly lower rate (Figure 2a and 2b).

Results on dehydrated fish fibres were very variable. Whereas the fresh fibres always contracted, those which had been dried and reconstituted generally did not. When they did contract they did so very much more slowly than the fresh. In general the fresh had finished contracting in 20–30 seconds while the dried was still contracting after 10–15 minutes. The degree of contraction was never as great in the dried as in the fresh (Figures 3a and 3b). The reason why the power

Contractility of fresh and reconstituted, dehydrated, beef fibres on addition of ATP

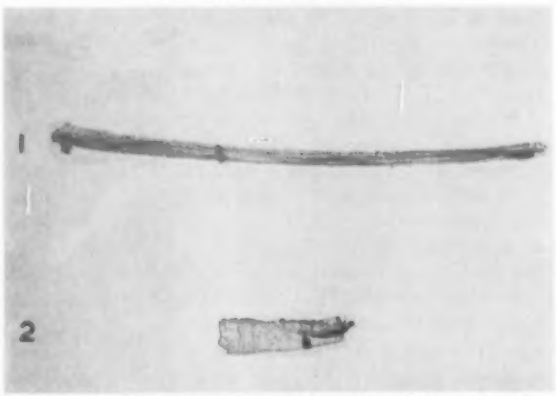

Figure 2a. A fresh beef fibre before (1) and 5 minutes after (2) addition of ATP. Magnification x100.

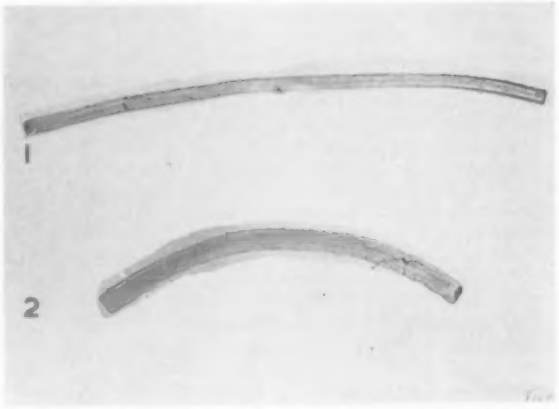

Figure 2b. A dehydrated beef fibre before (1) and 5 minutes after (2) addition of ATP. Magnification x100.

Contractility of fresh and reconstituted dehydrated cod muscle fibres on addition of ATP.

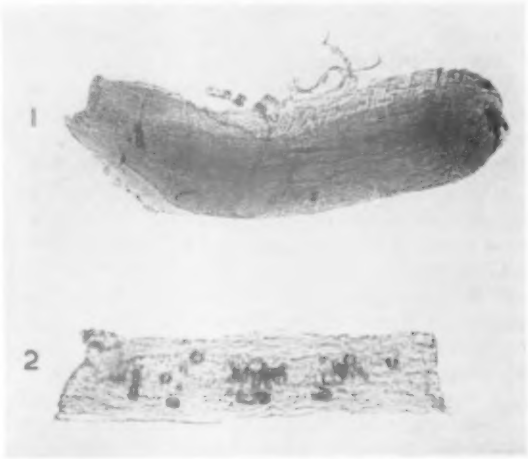

Figure 3a. Fresh (1) and reconstituted, dehydrated (2) cod muscle fibre. Magnification x75.

Figure 3b. The same 15 minutes after the addition of ATP. Magnification x75.

to contract is so often absent in reconstituted fish-muscle fibres has not yet been found. The retention of contractility seemed to be favoured by very rapid freezing (<5 mins.) and by the presence of cysteine, but freezing and drying conditions which would guarantee that the reconstituted fibres would contract have not so far been established.

Contractility of muscle fibres in meat and fish dehydrated by the VCD process was also examined. Cod muscle fibres were never found to be contractile. Those from beef or pork always contracted when ATP was applied, and there seemed little difference between the VCD material and that freeze-dried in the laboratory. This implied that the temperatures occurring towards the end of the VCD process did not damage the contractile mechanism of the dry beef or pork fibres.

To test this hypothesis, bundles of freeze-dried beef fibres prepared in a desiccator, were heated in open dishes for 1 hour at 22° C., 37° C., 55° C., 70° C., or 100° C. The contractility of individual fibres was observed as before. It was found that at temperatures of 55° C. or below, contractility was apparently unaffected. Fibres stored at 100° C., did not contract, while those at 70° C. were still slightly contractile.

DISCUSSION

In the preliminary experiments it was found that the greater part of the catalase in kidney was not destroyed by the VCD process. This, together with the persistence in muscle tissue of a comparatively labile enzyme like ATPase, suggests that many other enzymes will not be denatured in such drying operations. Certainly it is well established that many enzymes are not denatured in freeze drying *(13)*.

It is sometimes supposed that enzymes cannot act at low relative humidities. This idea probably arises from the fact that the growth of all microorganisms stops at R.H. < 70% *(28)*. Work carried out during and since World War II has shown that this view is incorrect. Lipase in freeze-dried raw meat continues to function slowly at moisture contents of 6.4, 4.7 and even 1.5% *(36)*, corresponding to 35, 23 and 5% R.H. respectively *(37)*. Kiermeier and Coduro have quoted numerous instances of enzyme action in dried foodstuffs *(23)*. They have also shown that amylase was active at 36% R.H. provided the dry material also contained fine capillaries *(24)*. Water is condensed in such capillaries even at a lower R.H. and this appears to permit enzyme action.

Dehydrated beef or fish prepared by freeze-drying or the modified VCD process, has a very porous structure and enzymes might well be expected to function in these foods at comparatively low moisture contents. The characteristic flavours which may develop in such foods during dehydration, and more particularly during storage, might easily result directly or indirectly from enzyme action. It is well-known that 'non-enzymic browning' reactions play an important part in the deterioration of dried foods, and it is not unlikely that the reactants for such 'browning' are supplied partly by enzyme action. This would explain why precooked VCD beef mince is much more stable than raw VCD beef. For example, at the Experimental Factory it has been found that at 12.5% moisture (on a NFS basis), precooked VCD minces will keep in fair condition for more than a year at 37° C. whereas beef dried to 11% moisture (54% R.H.) is barely edible after 1 month. It is not implied of course that the particular enzymes investigated here are the ones responsible for deterioration.

Many reports have been published on the properties of ATPase, so the need to experiment to find suitable conditions for the determination of this enzyme may not be obvious. There is however much disagreement in the literature *(1)*, and the behaviour of the enzyme may vary with the form in which it exists *(31)*. In addition the ATPase determined in this work was derived from beef or fish which had gone into rigor and there are few publications dealing with anything other than the enzyme from freshly-killed animals. It was also necessary to ascertain that actomyosin-ATPase was being measured and not some other enzyme.

The ATPase activity in presence of calcium was found to be entirely located in the water-insoluble fraction, though there was a heat-labile factor in the aqueous extracts which appeared to activate the ATPase. The nature of this factor was not investigated further since only ATPase in the insoluble fraction was being measured. Tests carried out on the water-insoluble fraction showed that there was no active myokinase or general apyrase present. The absence of myokinase was surprising since it is said to be difficult to remove it from actomyosin preparations *(1)*. Bowen and Kerwin *(6)* have shown that calcium does activate myokinase at pH 6.0, though the effect at pH 8.14 is unknown. The enzyme may therefore be present but unable to act.

At neutral pH and in the absence of potassium, actomyosin-ATPase can be activated by either calcium or magnesium *(1)*. The washed beef macerate was found to respond to either, the calcium being slightly more effective. When both were present together the ATPase was only slightly inhibited. This evidence confirms that what is being measured, is in fact actomyosin—ATPase. For determination of the actomyosin-ATPase in tissue, calcium is preferred as an activator since it inhibits other phosphate-producing enzymes.

The pH-activity curve of the calcium-activated ATPase in tris buffer was remarkably flat. The activity scarcely changed between pH 7.2 and 9.2. This is in marked contrast to the results obtained by Robinson using fowl muscle *(31)*. He found two distinct activity peaks at pH 6.6 and 8.8, respectively. These differences may be due to his use of a purified enzyme, or to the fact that his reaction mixture contained 0.1M KCl and employed glyoxaline buffers.

Normally, ATPase activity is determined by measuring the amount of inorganic phosphate released in the first minute of reaction at 37° C. In this work a 15 minute reaction period at 25° C. was chosen: the concentration of ATP and enzyme were adjusted so that the velocity of reaction was proportional to the amount of enzyme employed. This method minimised the effect of the unavoidable drop in reaction rate which occurs after the first 15 seconds *(38)*; it also economises in ATP.

Measurement of ATPase in beef or in cod fillet before and after dehydration, left no doubt that an appreciable fraction of the enzyme was not destroyed

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What you should know about oxidative deterioration

What is oxidative deterioration?

In fats and in foods containing fats, oxidative deterioration is caused by the reaction of oxygen in the air with the unsaturated portion of the fat molecule. This reaction produces free peroxide radicals which, in turn, appear to trigger a lengthy chain reaction, the result of which is the formation of a variety of aldehydes, ketones and acids. Once started, the breakdown cannot be reversed. In fact, if allowed to continue, it proceeds at an increasing rate.

Why is it important to food processors?

Oxidative deterioration, unless checked, rapidly takes its toll of fat-containing food products in the form of rancidity. Nothing destroys the reputation of a food product so quickly as the pungent, tallowy odor and flavor characteristic of rancidity.

How can you control oxidative deterioration?

Oxidative deterioration can be effectively controlled with antioxidants. Added to oxygen-sensitive fats and fat-containing food products, these chemical compounds step in to check the rancidity-producing chain reaction referred to above. Since the reaction leading to rancidity cannot be reversed, antioxidants can only prevent further deterioration. Hence, it is essential that they be added as early in the processing of the food product involved as possible.

Which antioxidant is best for you?

The principal food-approved antioxidants in use today are butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and propyl gallate. All are available from Eastman, alone or in solution formulations containing various combinations and ratios of BHA, BHT and propyl gallate, with or without a metal chelating agent.

The most effective and economical formulation for use in any given food product depends upon such factors as the food itself, how it is processed, methods of distribution and storage, and types of packaging. Advice and assistance in selecting the best formulation for your specific requirements is available from the Eastman food laboratories.

Where are these antioxidants available?

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in the process. Attempts to confirm this in fish by measuring changes in the salt solubility of the myofibrillar group of proteins were not very conclusive. When mild extraction methods were used, these proteins seemed to have become insoluble during dehydration. They could be brought into 'solution' by vigorous blending. However, they were then easy to sediment by high-speed centrifuging, compared to proteins extracted from fresh fish by milder treatment. This probably means they were not in true solution but existed as a very fine suspension. Drying does appear to render the myofibrillar proteins of fish insoluble in salt solutions (0.5M). Connell has also found that all the actomyosin in freeze-dried or VCD fish is insoluble in 0.5M postassium chloride *(9)*. In view of the rather unsatisfactory results obtained with fish and the fact that other workers had found it difficult to extract the myofibrillar proteins completely from fresh meat or from chicken *(1, 33)*, no attempt was made to determine the solubility changes in meat, before and after dehydration.

Beef muscle fibres are still able to contract in the presence of ATP after they have been dehydrated and reconstituted. For this to be so, most of the actomyosin molecule must be relatively undamaged. The smaller amount of contraction in the dehydrated fibres could be due either to a proportion of the molecules being completely denatured or to all the molecules being slightly altered. Results with fish fibres make the latter idea more likely. With these fibres, contractility is easily lost but even with the VCD process most of the ATPase activity survives. It does not seem possible to interpret these results in terms of classical ideas of denaturation as an "all-or-none" phenomenon. They appear to be in the nature of a series of changes brought about by increasingly severe conditions which agrees with modern concepts of protein denaturation *(32)*. In cod, actomyosin solubility is lost first, then contractility, and finally the ATPase activity.

Since this work was completed it has been found that Hopkins had already reported that dried muscle fibres would contract on rehydration and again when ATP was added. In this case fresh frog muscle was used. It was frozen by immersion in liquid nitrogen and freeze-dried *(20)*. Partmann *(30)* also has made a study of contractility in beef fibres tenderised by treatment with papain.

Improvements in storage properties of dehydrated raw meat and fish might well be obtained through control of their enzymic activity. This could be done in several ways. The foodstuff might be dried to a lower moisture content than is used for precooked materials. It might be given a prescalding treatment sufficient to denature proteins but insufficient to cook the food. Another possibility is the use of chemical inhibition of enzymes. This last method may raise problems of toxicity but it has already been employed in vegetable *(7, 11)* and meat *(17)* dehydration where carbon monoxide was used as the inhibitor. Further work is necessary to confirm that enzymes are responsible for the accelerated deterioration in raw meat and fish: if enzymes are implicated, those responsible must be identified.

SUMMARY

Changes which occur in actomyosin of beef and cod muscle as a result of dehydration have been investigated. Three criteria of denaturation have been used, namely, loss of solubility in salt solutions, loss of contractility of muscle fibres in presence of adenosine triphosphate and loss of adenosine triphosphatase activity. On dehydration, cod actomyosin becomes insoluble and the muscle fibres may or may not lose their power to contract, though about half the adenosine triphosphatase activity is not destroyed. Muscle fibres in the dehydrated beef examined were always contractile after reconstitution and they too retained about half their adenosine triphosphatase activity. These results are interpreted as being due to stepwise denaturation of actomyosin.

Acknowledgments

We wish to thank Mrs. M. I. Cox and her staff for carrying out fat and moisture determinations and Mr. J. R. Bendall of the Low Temperature Research Station, Cambridge, for his suggestion that contractility might be useful in studying the behaviour of actomyosin in dehydration.

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Dehydrocanned Apples

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(Manuscript received February 25, 1958)

DEHYDROCANNED APPLES are a modification of canned apples in which the prepared slices are dried to half their original weight prior to packaging. They possess attractive appearance, rich flavor, and are easily used for preparation of acceptable apple pie or other products. Their most obvious advantage is reduced weight, inasmuch as each can contains twice the usual quantity of apple solids.

The term "dehydrocanned" was first introduced by Kaufman in 1951 *(5)* in a study entitled "Costs and Methods for Pie-stock Apples." Availability of dehydrocanning for general use is provided by a public service patent to Kaufman, Powers, and Talburt *(6)*. The name "dehydrocanning" is similar to "dehydrofreezing," introduced by Howard and Campbell in 1946 *(4)*. Work on the dehydrofreezing of apples has been described in papers by Talburt, Walker, and Powers *(11)*, Talburt and Lindquist *(13)*, and Walker, Powers, and Taylor *(16)*.

The various factors involved in apple processing have been described by Smock and Neubert *(11)*. Variables relating to browning, such as effects of concentration and of chemical constituents, have been discussed by Hodge *(3)*, Mitchell and Peterson *(8)*, and Stadtman *(12)*.

EXPERIMENTAL PROCEDURE

Raw material. Winesap, Newtown Pippin, Rome Beauty, Jonathan, and standard Delicious varieties of apples with a firmness corresponding to 15 to 20 pounds by the Magness and Taylor fruit pressure tester *(2)* were peeled, cored, and cut into wedge-shaped slices of 10 to 14 pieces per apple. The slices were passed through a rotary reel-type separator where irregular chips were removed. The cut apple slices were dipped in a 0.5 to 1.0% salt solution to prevent browning of cut surfaces during delay in initial preparation of slices. Dip solutions of 1.0% sodium chloride and 1.0% citric acid in tap water were normally used for prevention of surface browning during drying. However, if the apples were bland in flavor the concentration of citric acid in the dip solution was increased to 2.0%. Dip times of 2 minutes were employed with occasional stirring during immersion.

Piece-temperature measurements on control of internal browning. Tests were performed on apple slices to determine the effect of temperature (and time) on internal browning. Thirty-gauge thermocouples were positioned in the centers of the slices and the slices were dried on wire-screen trays in a cabinet dryer. Piece center temperatures were continuously recorded. Periodically, batches were removed from the dryer and the incidence of brown centers recorded.

Drying operations. Cabinet, rotary *(10)*, tunnel, and belt-trough *(7)* types of dryers were used in the work. In all dryers, air velocities were made as uniform as possible throughout the drying zones. In tunnel dryers, cars of loaded trays were turned 180° at the midpoint of drying to improve product uniformity.

Trays used to support slices were of open construction (stainless wire-screen or narrow wooden slats) to provide uniform drying and to prevent undesirable localized overheating of slices with resultant browning.

Drying temperatures were generally in the range of 140 to 170° F. However, in the initial stages of drying, when the fruit was still relatively moist, drying air temperatures of 180° F. were occasionally used. Recirculation of air was minimized to keep the humidity low and thus aid in maintaining lower fruit temperatures. Rotary or belt-trough dryers, in which the drying air passed up through relatively deep, tumbling beds of product, also permitted the use of hot air inlet temperatures up to 180° F. At the bottoms of the moving beds in such dryers, those slices with direct exposure to the hot inlet air were only briefly exposed to the higher temperature. Evaporative cooling protected the bulk of the bed.

The loading of fruit in cabinet or tunnel dryers was 1.5 to 2 pounds per square foot of tray surface. With dryers using through-flow air (rotary and belt-trough), the weight of fruit per square foot of drying surface was several-fold greater.

A final product of two-fold concentration, or 50% weight reduction, was desired. During steam blanching following drying, a small amount of moisture was regained by the product. Therefore, allowance was made by slightly over-drying to about 55% weight reduction before blanching.

Two different procedures were used to determine weight reduction. When drying on trays, the simplest and most direct method was to weigh trays of slices "in" and "out" of the dryers. For dryers with continuous product flow, a refractometer, preferably with a Brix scale, was employed. Fresh undried samples (usually 300 grams) were liquefied in a blender and a portion of the juice was squeezed through a milk filter disc for measurement of initial Brix. The "double strength" samples from the dryer (300 grams) were blended with a weighed amount of water (300 grams) and then treated the same as the fresh. Refractometer readings were thereby obtained in the same range to minimize errors in the application of the refractometer Brix scale to apple juice.

Steam blanching. Blanching in steam was done after drying to inactivate enzymes and to heat for packaging. The common blanch was 4 minutes at 200° F. By raising the blanch temperature to 205° F. a denser product was produced, which allowed increased fill-in weights, but caused a slight loss in whiteness.

Stainless-steel wire-mesh belts, or trays, were used to support the slices during blanching. Loading was one to two pounds per square foot. The discharge ends of the blanchers were elevated to permit filling directly by gravity into the final containers.

Packaging operations. Two can sizes were used, No. 2 and No. 10, with tin coatings of 1¼ to 1½ base-box-pounds. Most can interiors had bright tinplate bodies and enameled ends. However, for comparison, cans with fully enameled linings (fruit types) were also used.

The slices, softened by blanching, were overfilled into the cans, and then compressed to pack tightly and displace air. Stainless-steel collars 3 or 4 inches high were used to facilitate the initial overfilling. Flat-bottomed plungers or tamps, which fitted snugly into the cans, were used to compress the apples. For compressing slices into No. 10 cans the tamps were provided with levers for application of 50 lbs. force to the slices. Filled cans were check-weighed.

Sucrose sirup with ascorbic acid *(1, 15)* and citric acid was added to some samples to fill spaces around slices and help reduce oxygen content. Concentrations were: sucrose 25%; ascorbic acid 0, 0.1, 0.25, and 0.5%; and citric acid 0 and 0.25%. The quantity of sirup added was generally around

* Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

10% of additional net weight per can. The sirup was added hot to the empty cans prior to filling in the slices and compressing.

Maximum vacuums were used within limitations of the cans. For No. 10 beaded cans, final vacuums were held below 20 inches to avoid paneling.

The cans were processed for 5 minutes in boiling water following seaming. The hot cans were then immersed in cold water to cool the product to about 100° F., then removed and stacked to air-dry.

Storage tests. The experimental packs described above plus 3 types of control or single strength solid pack apples, described below, were subjected to extensive storage tests:

1. Commercially packed Winesap and Newtown Pippin apples in No. 10 cans.

2. Laboratory packs of Winesap and Newtown Pippin apples in No. 2 cans. The soaking method was used, with immersion for one hour at 110° F. before blanching and filling.

3. Leached dehydrocanned apples of half the final soluble solids of regular dehydrocanned apples. Diced Winesap and Newtown Pippin apples were given prolonged soaking at 70° F. to reduce the soluble solids to exactly half of original and then dehydrocanned.

Storage times and temperatures were 6, 12, and 24 months at 34° and 70° F.; also 3 and 6 months at 34°, 90°, and 100° F.

Following storage, observations were made on vacuums, headspace, can corrosion, appearance (mainly color), texture, odor, and flavor.

RESULTS

Inhibition of browning. Both 1.0% salt and 1.0% citric acid, in combination, were required to protect the surfaces of slices. Neither agent alone was adequate, but together they were very effective and prevented darkening of surfaces during drying on trays. Severe abrasion of the treated surfaces of the slices would allow some enzymatic browning. Inhibition of internal browning was achieved by avoiding elevated piece temperatures for any considerable time.

Typical results of drying slices in cabinet dryers while checking both slice center temperatures and browning are given in Figure 1. After drying 60 to 80 minutes at 160° F., slice

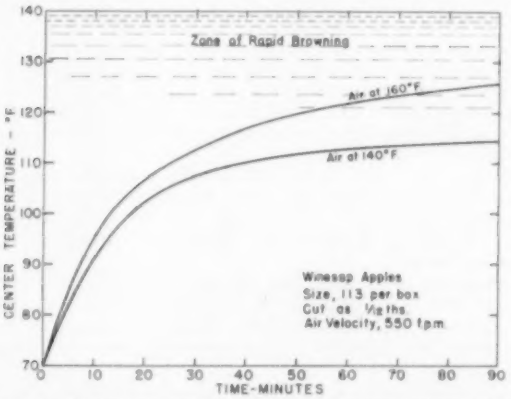

Figure 1. Center temperatures of apple wedges during drying.

temperatures began to exceed 120° F., and internal browning began to appear and increased with time. Drying the same lot of apples at 140° F. air temperature did not cause browning in 90 minutes.

After drying, bright color was generally stable for about 30 minutes at room temperature. Thereafter, internal browning appeared to increase. Consequently, blanching to inactivate enzymes was generally done within about 15 minutes after drying.

Eight different dryers were used during various periods of these tests. Four employed trays and cross-flow air, one had a single-tray and through-flow air, and 3 employed agitation and through-flow air. Minor abrasion of slices caused by some of the dryers was not noticeable in the final product.

Typical drying curves at constant temperatures in a cabinet dryer are shown in Figure 2. Most drying operations were completed within 60 to 90 minutes. Use of higher temperatures at the start of each drying cycle was effective in reducing times required.

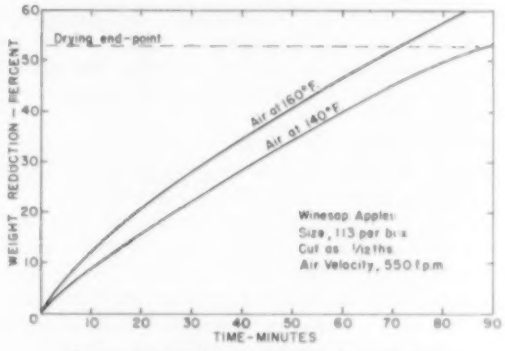

Figure 2. Drying time for apple wedges.

Blanching and filling. Blanching was essential to inactivate enzymes, to heat the slices for canning, to soften slices, and to reduce gaseous oxygen. The net weights of fruit in the cans were subject to variations dependent upon texture of slices, severity of the blanch treatment, and filling temperature. For example, Newtown Pippen slices blanched for 4 minutes at 205° F. and filled at 190° F. (center can temperature) generally gave a fill-in weight of 96 ounces per No. 10 can. However, when slices were blanched for 4 minutes at 200° F., the resultant fill was generally 90 ounces. Vacuums of over 15 inches in fully processed No. 10 cans could be attained without vacuum sealing if high filling temperatures were used. The qualities of the products from the 200° and 205° F. blanches were similar, with the lighter blanch giving a slightly brighter color and firmer texture.

Vacuum sealing was advantageous for the smaller No. 2 cans, in which vacuums as high as 27 inches were attained.

Storage tests. The most obvious differences in stored samples were in color. Light colors, recorded as cream or ivory, were regarded as favorable and darker colors, such as tan, as unfavorable. Increased darkening frequently correlated with increased can corrosion and with off-odors and off-flavors.

At 34° F. most dehydrocanned packs were good through 24 months. At 70° F. for 12 months many packs were rated as good; other packs were rated as unacceptable due to excessive browning. By 24 months at 70° F. a high percentage of packs showed some evidence of darkening. Ther re storage of dehydrocanned apples beyond one year might be definitely limited to selected conditions. The colors of dehydrocanned Winesap and Newtown Pippin slices were compared with the U. S. National Bureau of Standards' Ivory Standard: SKC-SRC-31, by means of the Hunter Color and Color Difference Meter. Freshly dehydrocanned slices had Rd values of about 40; after 1 year at 70° F. the values were about 25.

At 90° F. for 6 months all dehydrocanned samples showed darkening and were unacceptable.

All control packs, or single-strength regular canned apples, showed better stability at higher storage temperatures.

Special test lots of leached dehydrocanned apples, which were of actual single-strength soluble solids after dehydrocanning, showed practically the same rate of browning as noted in commercially canned apples.

As might have been predicted, cans with bright tinplate interiors proved to be much more effective in preserving color than were enameled cans. There was also good correlation between high vacuum and reduced corrosion. With No. 10 cans vacuums of 15 in. were preferred. With No. 2 cans, vacuums of over 20 inches were preferred. Addition of 10% of sirup containing 25% sucrose and 0.25% each of citric and ascorbic acids did not enhance storage stability. Variety of apple was not an important variable, provided apples were of suitable texture and processing types. Inasmuch as considerable softening occurred during blanching and heat-processing, initial firm texture was advantageous.

Trial commercial packs. Trial packs of several hundred No. 10 cans were made in each of two commercial plants. At one plant the equipment used included a tunnel dryer, a belt blancher, and a vacuum closing machine. At the other plant the equipment used was a small continuous-belt-type dryer, a belt blancher, and a conventional atmospheric closing machine. The process worked very well and appeared adaptable to further scaling-up.

Pie trials. The various packs of dehydrocanned apples have been used in pies with very good results. The precook method has been generally preferred over the deep dish or sirup-add-back method. The product has been found to rehydrate very well with an equal weight of water, or more, according to the desired pie-mix formula.

DISCUSSION

Preliminary experiments showed a number of operations to be unacceptable or unnecessary to the production of dehydrocanned apples. These operations are noted:

1. *Sulfiting* prior to drying revealed several objections, chief among which were discoloration of cans and product and formation of hydrogen-sulfide.
2. *Blanching* prior to drying produced an inferior dried product.
3. *Reducing oxygen content* by soaking apples prior to drying did not prevent oxygen uptake during or following drying.
4. *Accelerated drying*, which produced higher apple piece temperatures, gave internal browning of slices.
5. *Loose-filling* of final product gave increased corrosion of cans and browning of slices.

No published information was found on the drying of apples without prior sulfiting or blanching. During trials of conventional canning with the usual soaking procedure the tendency of apples to brown as a function of time and temperature was encountered. The onset of browning of slices has correlated well with a piece-temperature of around 120° F. It would be expected that some apples would brown much more readily than others, so that in actual practice the critical piece-temperature range might be somewhat wider. The data presented have been for wedge-shaped apple pieces. Smaller cuts dry faster while still retaining bright color.

Use of salt and citric acid as a protective dip is a new development in preparation of apple slices for drying. Salt alone does not prevent browning. Addition of ascorbic acid (1.0%) to the salt and citric acid dip solutions did not give a noticeably whiter product. The 1% citric acid may be replaced by 1.0% tartaric acid or 0.5% hydrochloric acid. Hydrochloric acid, however, gave red streaks with certain apples such as Red Winesaps, possibly due to leucoanthocyanins.

SUMMARY

A method has been developed for preparing canned, double-strength, apple pie stock. It involves dipping fresh slices in salt and citric acid, drying rapidly to about double strength, blanching to inactivate enzymes and to preheat for canning, filling tightly into cans, sealing hot, cooking, and cooling. Storage stability is good through one year at 70° F. but browning occurs on storage at 90° F. The chief advantages are economies in packaging, transportation, and storage.

Acknowledgments

The authors wish to thank Doris H. Taylor, L. H. Walker, and Harold A. Swenson for assistance during the development of this process.

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High Viscosity of Cell Wall Suspensions Prepared from Tomato Juice[a]

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(Manuscript received December 19, 1957)

PROGRESS TOWARD IDENTIFYING the factors that control the viscosity of tomato products has been made by many investigators *(1, 7, 8, 9, 10, 11, 13, 14, 15, 16, 19, 20, 22, 23,* and others). Two factors, the quantity and quality of pectic materials, and the quantity, configuration, and character of the insoluble solids have been shown to be of major importance.

While we were studying the role of insoluble solids in the viscosity of tomato juice, and were attempting to isolate the insoluble solids, we obtained a result that was totally unexpected and we believe previously undescribed. We observed that when tomato juice was centrifuged and the sediment was washed repeatedly with distilled water by centrifugation, viscosity at first dropped, then rose to a value far exceeding that of the original juice. In some cases, the washed product thickened to a semi-gel.

The present paper proposes to describe in detail the thickening effect just mentioned, to disclose the properties and behavior of the thickened product and of various juice fractions, and to provide new fundamental information on the factors determining tomato juice viscosity.

PROCEDURE AND RESULTS

Effect of washing. Changes in viscosity of a pectin-rich unhomogenized, commercial tomato juice brought about by centrifuge washing are shown in Table 1. The juice was centrifuged 9 times under identical conditions (2000 r.p.m., 10 min., 25° C.) in an International[c] size 1 centrifuge. After each centrifugation, the supernatant liquid was decanted and replaced with distilled water. Volume of original juice was 400 cc.

Viscosity, as measured at 25° C. with a Brookfield viscometer,[c] rotor No. 2 at 60 r.p.m., decreased initially as distilled water was substituted for the original serum (soluble solids fraction). As the washing procedure continued, however, viscosity gradually increased, reaching a value more than double that of the original juice at the ninth wash.

Associated with the increase in viscosity was an increase in the volume of the centrifuged insoluble solids. These swelled, and packed less tightly in the centrifuge tube as washing progressed. At the same time the soluble solids content and the conductivity of the sample decreased (Table 1).

The microscopic structure of the insoluble solids *(23)* is shown in Figure 1. Only two principal structures were visible.

TABLE 1

Increase in viscosity attendant on the washing of soluble solids from tomato juice by centrifugation

No. of centrifuge washings of original juice[1]	Viscosity, apparent centipoises	Soluble solids, % (Abbe)	Volume of insoluble solids after centrifugation, cc.	Electrical resistance, ohms[2]
0	240	5.8	148	6
1	200	2.5	153	14
3	240	0.7	168	30
5	290	0.3	181	175
7	380	0.1	200	650
9	500	0	223	1500

[1] After each centrifugation, the supernatant liquid was decanted and replaced with distilled water. Volume of original juice was 400 cc.

[2] With the conductivity cell used, the resistance of N/10 KCl was 7 ohms.

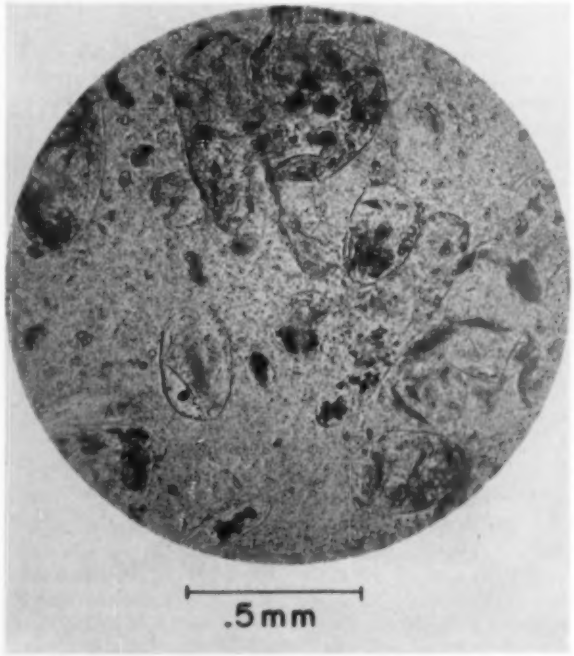

Figure 1. Insoluble solids of tomato juice, showing numerous granules separated from cells, single and clustered granules within cells, and walls of the cells.

These were tomato cell walls, visible as lines outlining the predominantly spherical cells, and numerous small granules, occurring singly outside the cells and commonly in clusters within the cells. The relative importance of these structures in determining total viscosity will be shown later.

It became apparent that tomato juice could be washed simply and quickly by sieving. Accordingly, a specified volume of juice was poured onto a 200-mesh sieve and washed gently with the distilled water for 15 minutes. Soluble materials, as well as the bulk of the small insoluble granules, passed through the sieve. Cell walls, mostly in the form of near-spheres rang-

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 15, 1957.

[b] One of the laboratories of the Eastern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

[c] Mention of specific products does not imply endorsement of them by the Department to the possible detriment of others not mentioned.

centrifuge run, the supernatant layer was decanted and replaced with distilled water, which then was mixed with the settled layer or insoluble solids prior to re-centrifugation.

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How to Measure Brine Strength on Different Hydrometer Scales

The most common method of measuring brine strength in industry is to use some type of hydrometer. Every hydrometer sinks into a liquid until it has displaced a weight of the liquid equal to its own weight. The scale divisions on a hydrometer are not usually of equal length, since the volume of displaced liquid increases as more of the stem is immersed.

Using a hydrometer is a relatively simple process—but reading the hydrometer scale is complicated by this fact: the scale may vary from plant to plant because hydrometers may be used to measure strength of other liquids, as well as salt brine. To help clear up any possible confusion, here are an explanation and a comparison of the five most common hydrometer scales used for measuring brine strength.

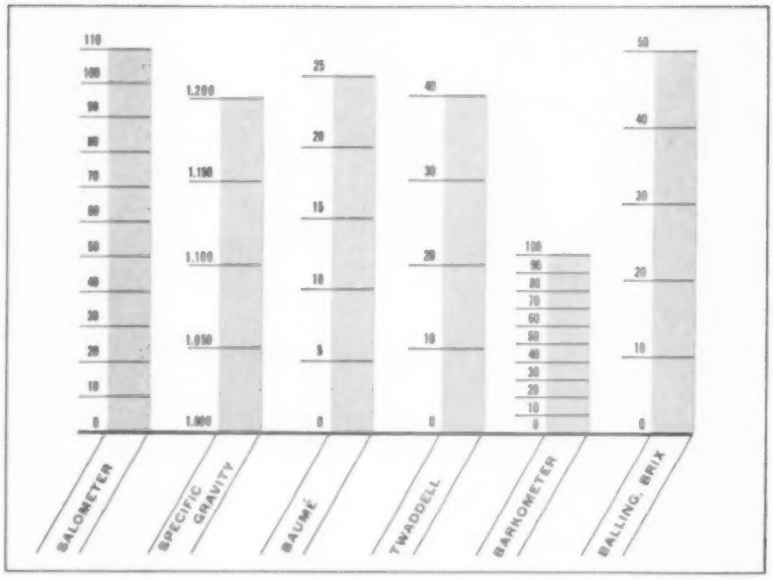
SALOMETER SCALE. This is by far the most common of all the hydrometer scales used for testing brines. The scale indicates directly the per cent saturation of the brine, reading 0° S. in pure water, and 100° S. in fully saturated brine. The salometer uses the values of Gerlach, meaning that 100%-saturated brine contains 26.395% salt by weight. Each salometer degree, then, represents 0.2639% salt.

The salometer reading expresses the per cent of saturation. Thus, a brine of 40° S. strength is 40% saturated, and contains 40% of 26.395%, or 10.558% salt by weight.

SPECIFIC GRAVITY SCALE. This reads the specific gravity of the brine *directly*. These hydrometers may be obtained with the entire length of scale covering a limited range of specific gravities, thus permitting great accuracy.

BAUMÉ SCALE. This scale was originally intended to have each degree equal a per cent of salt in the brine. But this is now only a rough approximation. The Baumé scale reads 0° Bé. in pure water, 24.6° Bé. in fully saturated brine. Also, a factor of "modulus" is needed to translate degrees Bé. to specific gravity, since the scale divisions are of equal length. This modulus has been standardized at 145, so that degrees Bé.=145–145/sp.gr.

TWADDELL SCALE. Named after its inventor, the Twaddell scale reads 0° Tw. in pure water, 40.8° Tw. in fully saturated brine. Each increase of 0.005 in specific gravity causes 1° increase on the Twaddell scale. Thus, the number on the right of the decimal point of the specific gravity, divided by 5, is the degrees Tw. For example: 1.140 sp.gr. is 140/5, or 28° Tw.



COMPARISON OF COMMON HYDROMETER SCALES

(Chart gives quick, visual relationships of readings on the salometer scale to readings on other scales.)

BARKOMETER SCALE. Used extensively for testing tanning liquors, the Barkometer scale reads 0° Bk. in distilled water, and 204° Bk. in fully saturated brine. Each increase of 0.001 in specific gravity causes 1° increase on the Barkometer scale. Thus, the number on the right of the decimal point of the specific gravity is the degree Bk. For example, 1.025 sp.gr. is 25° Bk.

The hydrometer scales described above are usually calibrated for brines at 60°F. temperature. When testing brines at other temperatures, it's necessary to make certain corrections...or to use a specially designed hydrometer. You can get a table showing proper temperature corrections, plus other data on measuring brine strength, from International Salt Company.

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ing in diameter from 100 to 500 microns, were retained on the sieve. During the sieve-washing the cell walls swelled, just as they did during the centrifuge washing. Walls were removed from the sieve and made to the original juice volume with distilled water. Figure 2 shows the washed cell walls and the portion of granules entrapped within the walls.

Several juices were washed in this manner; all gave products of increased viscosity (Table 2). The increases were large, ranging from 1½- to 4-fold. Whereas the original juices were relatively thin liquids, some of the washed products resembled plastic solids more closely than liquids. Sample No. 3 (850 apparent centipoises), for instance, would not flow from a horizontal test tube (Figure 3B), and when lifted with a spatula, formed a mounded mass on the blade. There was a tendency for the products from hot-break (pectin-rich) juices to thicken somewhat more than those from cold-break (pectin-deficient) juices.

Figure 2. Sieved, washed, and diluted tomato juice cells. Walls outlining the cells and entrapped granules within the cells are seen.

TABLE 2

Increase in viscosity associated with the washing of soluble solids and small insoluble particles from tomato juice by sieving

Sample	Viscosity, apparent cp.		Total solids, %	
	Original	Washed[1]	Original	Washed[1]
1. Commercial juice, hot break	235	480	....	.....
2. Commercial juice, hot break	230	520[2]	6.1	0.48
3. Commercial juice, hot break	185	850[2]	6.7	0.74
4. Commercial juice, cold break	220	430	6.3	0.50
5. Commercial juice, cold break	160	255	....	.....
6. Commercial juice, cold break	145	210	6.0	0.38
7. Laboratory juice, unsalted	130	300	4.9	0.57
8. Laboratory juice, unsalted	60	215	....	0.39
9. Laboratory juice, raw, unheated	95	115	....	0.35

[1] Juices were poured onto a 200 mesh sieve, washed with distilled water for 15 minutes, and made to their original volumes with distilled water.

[2] Viscosities above 500 apparent cp. were determined with Brookfield rotor No. 3 at 60 r.p.m.

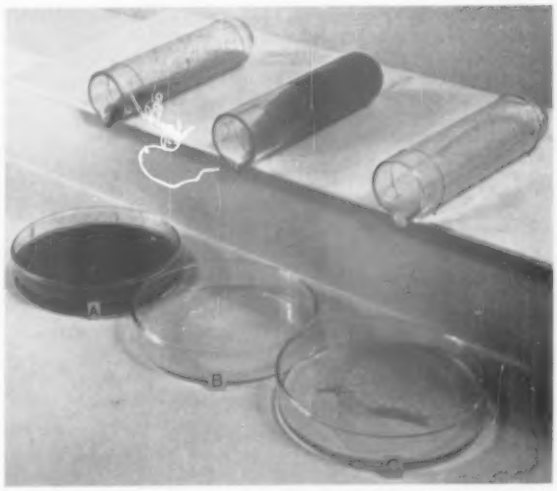

Figure 3. Demonstration of the differences in viscosity between: A, whole tomato juice; B, sieve-washed juice product; and C, homogenized pure cellulose walls from the juice. Viscosity of samples A, B, and C was 185, 850, and 700 apparent centipoises, respectively.

Tomato juice fractions. In order to picture the distribution of solids of a tomato juice as affected by the centrifuge- and sieve-washing procedures, Figure 4 is provided. As previous workers have found *(3, 11)* about 87% of the total solids were soluble (serum). This fraction, as is well known *(3, 11, 24)* was composed chiefly of sugars, organic acids, proteins, mineral salts, and pectins and other polysaccharides. The remaining 13% of the solids, the insolubles, consisted principally of small carotenoid and proteinaceous granules and cellulosic cell walls *(12)*. Sieve-washing the insolubles separated more than half of the granules from the cell walls.

The most interesting feature of the fractionation was the demonstration that viscosity of the whole juice was almost entirely dependent on one relatively small fraction. The washed

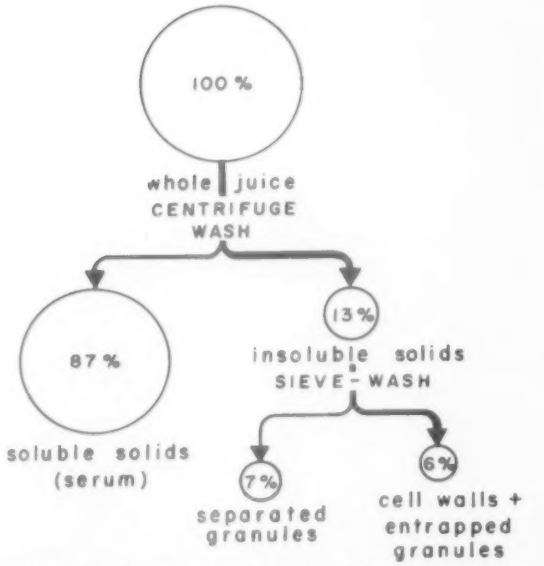

Figure 4. Diagram of fractionation of tomato juice by centrifugation and sieving. The per cent of the total solids comprised by each fraction is shown.

cell walls, comprising only 6% of the total solids, formed a suspension whose viscosity was twice that of the original whole juice (Table 3). In the absence of cell walls the other juice fractions possessed no significant viscosity. The serum, for instance, although containing 87% of the total solids and the bulk of the pectic materials, had a viscosity of only 2 cp. Viscosity of the granules suspension alone was only 5 cp. It was clear, therefore, that the cell wall fraction constituted the backbone of whole juice viscosity, and that the serum contained substances which inhibited the development of maximum viscosity in whole juice.

Properties of the washed product. Various substances were added to the washed juiced products (i.e., washed insolubles) in order to determine their properties and to investigate the causes for the high viscosity. The addition of serum caused a sharp drop in viscosity (Table 4). Subsequent removal of the serum caused viscosity to return again to its high value; thus the change in viscosity was reversible.

Addition of sucrose, a natural component of serum, to the washed products had little effect on viscosity. Viscosity also was maintained at a high level in the presence of glycerin, urea, and ethyl alcohol. However, the addition of soluble pectin, citric acid, sodium chloride, or calcium chloride caused a marked lowering in viscosity. In general, viscosity was stable in the presence of nonelectrolytes, but was decreased by electrolytes. Relatively small amounts of electrolyte produced the effect. We have found that even the quantity of electrolytes occurring naturally in fresh tomatoes is sufficient to keep viscosity at a low level.

Confirmatory evidence that the electrolytes in tomato juice depress viscosity was obtained by treatment of a juice with synthetic ion-exchange resins. Both cations and anions were removed from the serum fraction, which was recombined with the insoluble-solids fraction, then separated again and deionized. Nine repetitions of this treatment were needed to complete ion removal; the deionized juice had increased viscosity. Further work on the use of deionizing resins is planned, since their use would produce minimal changes in total juice composition.

TABLE 3

Viscosity of tomato juice fractions

Juice or juice fraction	Viscosity, apparent cp.	Solids content[1]	Electrical resistance
		%	*ohms*
Original whole juice	240	6.3	7
Soluble solids only (serum)	2	5.5	7
Insoluble solids, washed	500	0.8	1500
Separated granules, washed	5	0.45	.....
Cell walls plus entrapped granules, washed	500	0.35	1650

[1] For the fractions, same concentration as in original juice.

TABLE 4

Effect of various substances on viscosity of the washed product from tomato juice

Substance added	Concentration of substance	Viscosity, apparent cp.		
		Washed product		Standard error[3]
		A[1]	B[2]	B
	%			
1. None	....	345	890	12
2. Juice serum	3	180	330	6
3. Soluble pectin	0.2	210	200	7
4. Citric acid	0.2	120	205	21
5. Sucrose	3	390	980	12
6. Glycerin	3	375	920	24
7. NaCl	0.2	155	315	31
8. $CaCl_2$	0.2	150	200	15
9. Ethanol	50	500	895	42

[1] Prepared from cold break juice; solids content, 0.50%.
[2] Prepared from hot break juice; solids content, 0.74%.
[3] Standard error of measuring viscosity was relatively high in some samples, owing to clumping in the samples. Samples of product A showed the same relative errors.

Effect of homogenization. Apart from its direct effect on viscosity, the washing of tomato juice had an important indirect effect. In most cases the washed products were considerably more susceptible to mechanical break-up than were the original juices, and homogenization produced a degree of thickening not achieved with the whole juices (Table 5). This was true particularly of the products from cold-break juices.

With the hot-break juice product that thickened most during the original washing (sample 2, Table 5), the standard homogenizing treatment (2 min. treatment in an electric blender) gave no further increase in thickness. Microscopic examination showed that most of the cell walls remained whole and unbroken during the treatment. Only slight thickening was produced by prolonged homogenization. Apparently in this case, the relatively large quantities of pectic substances in the walls acted as plasticizers and rendered the walls less brittle and more resistant to mechanical stresses. Following enzymatic removal of the pectins (*23*), homogenization was effective in disrupting the cells and in increasing viscosity.

Cellulose wall suspensions. The question arose as to what substance was primarily responsible for the high viscosities described in previous sections of this paper. Although tomato cell walls were identified as the indispensable structures, they were not isolated in pure form or as a single chemical substance. It is widely known that most fleshy plant cell walls contain a number of substances, including cellulose, hemicellulose, protein, and pectin compounds (*4*, *5*, *6*, and others).

The effect on viscosity of removing all substances except cellulose from the cell walls of tomato juice is shown in Table 6. The walls were boiled in 2% sulfuric acid and in 2% sodium hydroxide, and then extracted with ethyl alcohol and ether, just as in a crude fiber determination (*2*). They finally were made to their original juice volume with distilled water, without being dried previously. The viscosity of all juices decreased with the treatments, indicating that the non-cellulosic components of the walls made an important contribution to viscosity (Table 6). Yet the pure cellulose walls alone, in the form (Figure 5) and concentration at which they occurred in the whole juice, yielded suspensions of appreciable viscosity. The suspensions were colorless, translucent, and heat-stable.

The cellulose wall suspensions responded quickly and strikingly to homogenization. Viscosity of sample 1 (Table 6),

TABLE 5

Effect of homogenization on the viscosity of tomato juice before and after the removal of soluble materials

Sample	Original juice		Washed juice product[1]	
	Viscosity, apparent cp.		Viscosity, apparent cp.	
	Not homogenized	Homogenized[2]	Not homogenized	Homogenized[2]
1. Hot-drink juice	235	300	480	830
2. Hot-break juice	220	375	890	810
3. Hot-break juice	210	295	485	885
4. Cold-break juice	200	240	310	760
5. Cold-break juice	190	240	370	940
6. Cold-break juice	160	260	255	620

[1] Juices were washed on a 200 mesh sieve with distilled water for 15 minutes.
[2] Samples were treated for 2 minutes in an electric blender.

TABLE 6

Viscosity of cellulose cell wall suspensions prepared from tomato juices

Sample	Original juice	Cellulose wall suspension		
		Viscosity, apparent cp.		Solids[1] content
	Viscosity, apparent cp.	Original	Homogenized	
				%
1	375	100	500	0.21
2	220	140	880	0.24
3	210	100	285	0.22

[1] Cellulose concentration was the same as that of the original juice.

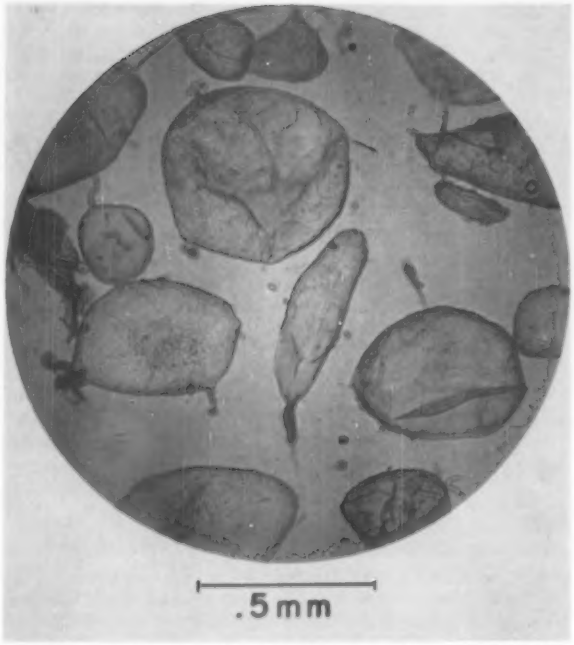

Figure 5. Tomato cell walls following the removal of all substances except cellulose. Compare with Figures 1 and 2.

for instance, increased from 100 to 500 apparent cp. during the standard homogenizing treatment. The latter value far exceeded that of the original whole juice, despite the fact that the whole juice contained about 30 times as much solids. In fact, the homogenized cellulose wall suspensions were thicker, per unit concentration, than any of the commonly used thickening agents such as starch, pectin, gelatin, methyl cellulose, or sodium alginate *(21)*. Figure 3C gives a visual impression of the thickness of a sample containing only 0.24% of cellulose.

Figure 6. Tomato cellulose walls following homogenization.

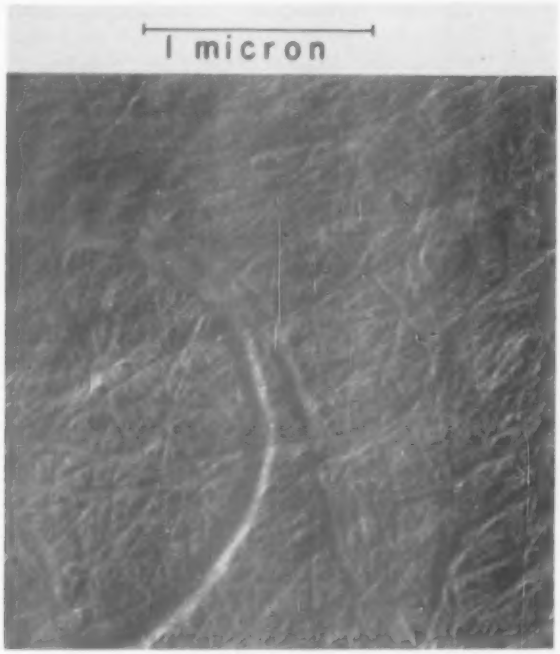

Figure 7. Electron micrograph of tomato cellulose wall, showing network of cellulose microfibrils.

Microscopic studies showed that the homogenizing treatment destroyed the near-sphericity of the cellulose shells and shredded the walls into twisted ribbons and irregular sheets (Figure 6). This change in structure probably was basic to the increased viscosity. The fine structure of the cellulose walls is shown in the electron micrograph (Figure 7).

DISCUSSION

From an interpretative or fundamental viewpoint, the present findings are significant. They reveal tomato juice as having a potential for thickening not heretofore recognized. They cause a re-evaluation of the factors known to effect consistency and indicate that a new factor, electrolyte content, should be given a position of importance. They de-emphasize the role of soluble pectins *(11)* but reaffirm and strengthen the role of insoluble solids *(7, 11, 20, 23)*. They show consistency to be dependent primarily on the structure and composition of the tomato cell wall.

The exact manner in which electrolytes affect juice consistency is the subject of our present research. Only the cell wall fraction of the juice is involved. Apparently the surfaces of the walls bear electric charges which help maintain the walls in suspension, thereby contributing to viscosity. Insoluble pectin, intimately associated with the cellulose fibrils in the walls, doubtless contributes to the electric charges. In the absence of soluble electrolytes, the charges exhibit their maximum effect. The walls swell, bind quantities of water, and promote high viscosity, just as potato starch granules in suspension swell during gelatinization and give rise to increased paste vis-

cosity *(17, 18a)*. Homogenization, by fragmenting the walls and increasing the surface area, may augment these effects. In the presence of electrolytes, however, the charges on the walls become neutralized, the walls shrink, and a drop in viscosity ensues.

Tomato cellulose suspensions exhibit at least two properties which are not commonly associated with cellulose suspensions. In the first place, tomato cellulose forms relatively thick suspensions at dilute concentration, and secondly, the suspensions are thickened further by a very brief homogenizing treatment. In these respects the suspensions differ quantitatively from those of wood or cotton natural cellulose *(18b)*. One reason for these differences in behavior is revealed by microscopical, x-ray, and infrared studies of the structure of the walls. The cellulose of tomato walls, although fibrillar in appearance, is essentially amorphous; that of wood and cotton is largely crystalline. Further research on the structure and composition of tomato cellulose walls is being pursued.

Since the cell walls of apples, apricots, and peaches are generally similar in structure and composition to those of tomatoes, it might be expected that nectars of these fruits would show the same general response to the removal of electrolytes as does tomato juice. Our preliminary experiments indicate that this indeed is the case, and that the phenomenon, therefore, is widespread.

SUMMARY

Experiments have shown that the viscosity of tomato juice is kept at a relatively low level by the presence of naturally-occurring and added electrolytes. Removal of electrolytes, including soluble pectins, organic acids, and mineral salts, may cause the remaining fraction of juice to thicken to a semi-gel. Electrolyte content thus is established as a newly-discovered factor in determining tomato juice viscosity.

Only a small fraction of the juice solids is directly involved in the thickening process. Tomato cell walls, comprising less than 6% of the total solids and less than half of the insoluble solids, have been shown to be the juice component essential for high viscosity. As electrolytes are removed, the walls swell, become increasingly hydrophilic, and give rise to increased viscosity. Viscosity remains high in the presence of non-electrolytes such as sucrose, glycerin, and ethyl alcohol, but decreases as the electrolytes are returned to the juice.

In most cases the removal of electrolytes from juice accentuates the thickening effect of homogenization.

Of the substances comprising the tomato cell wall, cellulose has been found to be the single substance most closely related to viscosity. Tomato cellulose alone has formed suspensions that are thicker, at equivalent concentration, than most of the common thickening agents.

The significance of the new information is discussed.

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Effect of Packaging Materials and Techniques on Shelf Life of Fresh Poultry Meat*

(Manuscript received March 7, 1958)

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VARIOUS INVESTIGATORS have reported upon the spoilage processes in poultry meat and upon means of delaying the onset of this spoilage. Ayres *et al. (2)*, Kohler *et al. (4)*, Ziegler and Stadelman *(10)*, Vaughn *et al. (6)*, Wells *et al. (8)* have reported an extension of the shelf life of fresh chicken meat by antibiotic treatment prior to packaging. Results of these investigations have shown that the use of antibiotics is effective but that such treatment causes a large increase in the numbers of yeasts which develop on the meat.

Spencer *et al. (7)*, Kish *(4)* and Stewart *(8)* have studied the effects of various packaging materials on the quality of fresh dressed chicken fryers. It was found by Spencer *et al. (7)* that the type of packaging film has an effect on the shelf life (bacteriologically) of fryers not treated with antibiotic. Kish *(4)* found significant changes in keeping quality of packaged chickens as measured by the presence of off odors. Stewart *(8)* made the observation that oxygen can cause discoloration in poultry meat under certain conditions. Shelf life of poultry meat is also affected by plant sanitation and the use of low holding temperatures, Gunderson *et al. (3)*, Ogilvy and Ayres *(5)*. Ayres *et al. (1)* and Walker and Ayres *(7)*, have observed that the predominant types of bacteria developing under 4.4° C. storage and present at time of spoilage belong to Achromobacter and Pseudomonas genera.

Since a change in some factor in an environment should affect the microflora under the influence of such an environment, it seemed worthwhile to explore one aspect, the effect of packaging. More specifically, the primary purpose was to determine the effect on spoilage organisms of packaging films which differed in their permeability to gases and water. Some study was also made of the possible contribution of containers and absorbant materials to the fungal flora affecting antibiotic-treated poultry meats.

EXPERIMENTAL METHODS

Chickens used in this study were obtained from the Purdue Poultry Farm and brought to the poultry processing laboratory for dressing. They were killed by cutting the throat and allowed a one-minute bleed time, after which they were scalded in water at 60° C. in a batch type scalder for 40 seconds. Picking was done on a mechanical picker. The birds were eviscerated and halved. One-third of the birds were chilled in ice water, one-third in ice water containing 30 p.p.m. chlortetracycline, and the remaining third in ice water containing 30 p.p.m. oxytetracycline. All birds were chilled for 2 hours. After treatment the halves were placed in cardboard trays which contained absorbant pads. They were then packaged with a wrapping of cellophane (300 LSAT), vinylidene chloride copolymer sheet, (unevacuated) or in vinylidene chloride copolymer bags which were partially evacuated to a vacuum of 10 inches. Three replications were made, using 108 halves in each trial; 36 halves wrapped in cellophane, 36 halves in vinylidene chloride copolymer sheet and 36 halves in vinylidene chloride copolymer evacuated bags. All birds were stored in a walk-in refrigerator at 34° F. Spoilage was determined by the development of odor and slime. Microbial changes occurring during storage were followed by the slime smear method of Ziegler *et al. (9)*.

Development of odor and microbial increases on the birds packaged under partially evacuated atmospheres were determined by following one or two representative birds and repackaging each time examined. When spoilage of the control package(s) was evident, the remainder of the birds were examined. Any found to be unspoiled (no off-odor or slime) were repackaged under similar conditions as previously and held until odor and slime developed.

RESULTS AND DISCUSSION

Influence of packaging materials on bacterial spoilage. Poultry meats which had received no treatment other than chilling in ice water and packaged with a wrapper of cellophane did not show evidence of off odors until they had been held under 34° F. storage for 11 days. Meat held under identical storage conditions but packaged with a wrapper of the highly impermeable vinylidene chloride copolymer sheet developed off odors at 11 days also. This would indicate that if either cellophane or vinylidene chloride copolymer have any toxicity for bacteria they are of equal magnitude, which would seem unlikely; therefore, we may reasonably infer that neither possesses any such properties. This is further substantiated by the fact that pieces of these films when placed on Agar plates seeded with spoilage organisms did not inhibit growth either directly underneath the film or at the periphery. Whereas the storage times for birds wrapped in cellophane and vinylidene chloride copolymer were the same under non-evacuated conditions, birds in vinylidene chloride copolymer bags from which the air was partially evacuated had a storage time four days longer than that obtained without evacuation.

As can be seen in Table 1, this partial evacuation of the containers gave similar increases in shelf life

TABLE 1

Influence of various packaging materials on storage times (Days to spoilage)

Treatment prior to packaging	Cellophane	Packaging materials vinylidene chloride copolymer	Vinylidene chloride copolymer (evacuated)
Chilled only	11.1	11.3	15.2
30 p.p.m. CTC	17.2	17.8	19.7
30 p.p.m. OTC	16.9	17.7	19.8

* Journal paper no. 1248 of the Purdue Agricultural Experiment Station.

of the meat regardless of the treatment prior to packaging; that is, even with antibiotic treatment the treated birds stored in evacuated bags had longer storage times than those packaged without partial removal of the air.

With the antibiotic treated birds, cellophane and vinylidene chloride copolymer film gave nearly identical results. CTC treated chickens wrapped in cellophane had a storage time of 17.2 days whereas the vinylidene chloride copolymer wrapped birds had a storage time of 17.8 days—an insignificant difference. Chickens treated with OTC and wrapped in cellophane had an average storage time of 16.9 days. Those wrapped in vinylidene chloride copolymer film were, at an average, 17.1 days old before off odor developed. Where only slight differences in total storage time were found between cellophane and vinylidene chloride copolymer sheet, more significant differences were found between vinylidene chloride copolymer wrapped evacuated and non-evacuated packages. CTC treated birds packaged in the evacuated bags had a shelf life of 19.7 days while the OTC treated birds under the same conditions had an almost identical storage time of 19.8 days, indicating in addition to the effect of evacuation, the nearly equal effectiveness of CTC and OTC when used at levels of 30 p.p.m. as has been found by other investigators, Ayres *et al. (2)*. These results would indicate, too, as has been previously mentioned that the films as such have no bacteriostatic effects but do inhibit the development of spoilage organisms by limiting the amount of oxygen available for microbial proliferation when the bags are evacuated prior to storage.

Influence of package on antibiotic effect. That oxygen tension can also modify the results of other techniques to extend storage times is suggested by Table 1. It can be seen from these values that the effect of the antibiotic does not appear to be as great under conditions of reduced oxygen as they are where evacuation of the bag was not practiced. Under the conditions of reduced oxygen tension created by evacuation of the container the antibiotic (both CTC and OTC) accounts for 23% of the total shelf life; under conditions where air was not removed from the package the antibiotic accounts for 36% of the total storage time. In other words, under nearly complete aerobic conditions antibiotic treatment is 13% more effective. It must be remembered, however, that although under conditions of partial evacuation the antibiotics appear to be less effective, the total storage time is still greater because of the additional inhibiting influence of reduced oxygen tension.

It should be noted that in the case of the untreated chickens there was one bird which developed a flora almost entirely composed of yeast. This is the first time and the only time in which we have ever noted this type of spoilage on untreated chicken meat held under our storage conditions.

In order to determine the part that the trays and absorbant pads used to package the birds might be playing in the fungal contamination of the meats absorbant trays, non-absorbant trays, and absorbant pads were analyzed for yeast and mold numbers. Surface washings of these materials were plated on potato dextrose Agar which had been acidified to pH 3.5, on Agar containing 10 p.p.m. chlortetracycline and on Agar with 10 p.p.m. oxytetracycline. None of these materials was found to have more than 10 yeast and mold organisms per square inch of surface, a rather insignificant number when compared to the normal contamination of the birds.

The exact point at which off odors developed on some of the birds was difficult to determine. It became obvious that the changes in treatment and techniques in packaging gave rise to differences in flora which in turn gave rise to differences in kinds and intensity of off odors. The typical "dirty dish rag" odor ascribed to spoiled untreated poultry did not adequately describe the odors associated with treated birds or birds packaged in evacuated impermeable films. The odor varied from "dish rag" to *sour*, to *musty*, to *yeasty*, to an odor described as "cured ham." There were even some treated birds upon which visible yeast colonies and mold mycelium could be seen which did not have an off odor. They were, nevertheless, considered spoiled.

SUMMARY AND CONCLUSIONS

It can be reasonably concluded that vinylidene chloride copolymer and cellophane films used for packaging poultry meat do not exert a direct bacteriostatic effect on the spoilage organisms which develop on poultry meats. The technique of partially evacuating the air from packages wrapped in impermeable films, however, tends to inhibit bacterial growth by virtue of reduced oxygen tension. This reduction in oxygen tension has some influence also on the effect produced by antibiotic treatment, efficiency being somewhat reduced by evacuation of the package. It was also observed that the type of film and treatment may influence the type of off odor which persists at the time of spoilage.

Trays and absorbant pads used to package poultry meats may make some contribution to fungal flora especially on antibiotic treated birds but this contribution would appear to be of little or no consequence when compared to the microflora already present on the birds when they are packaged.

Acknowledgments

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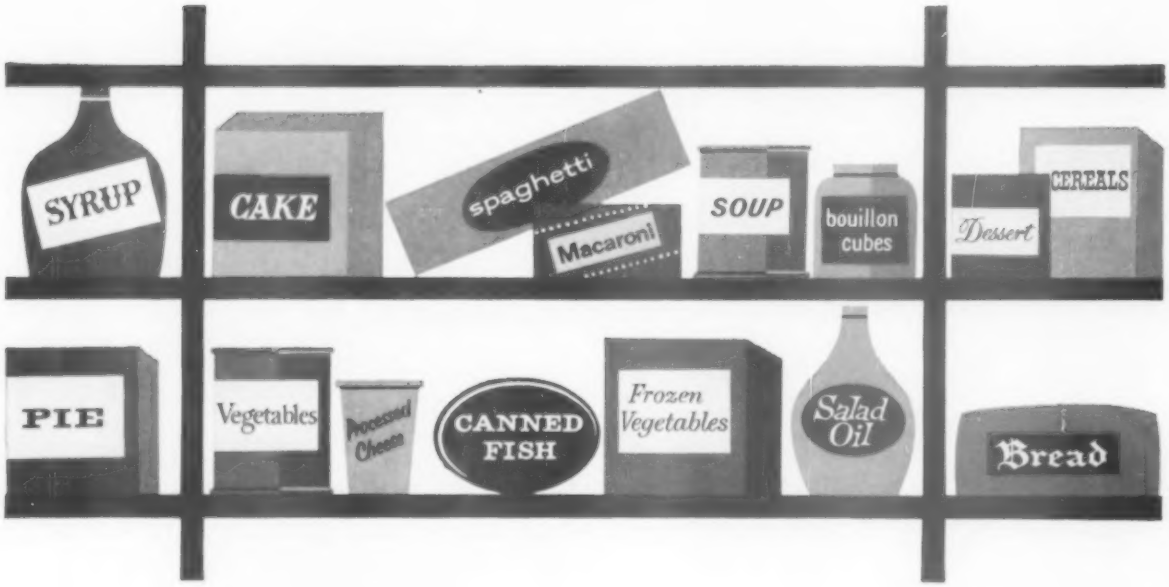

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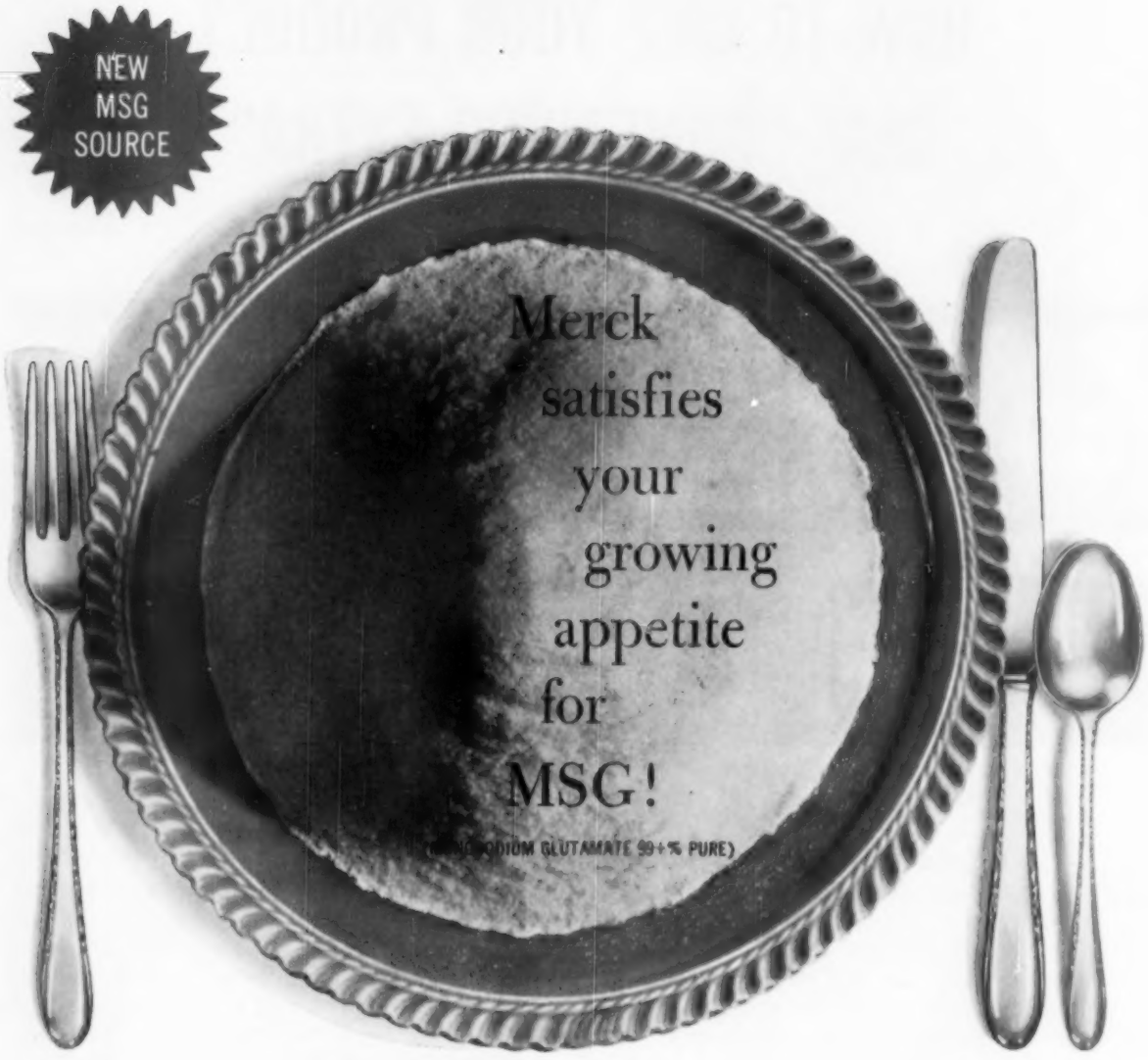

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Notes and Letters

Determination of the Conversion of Chlorophyll to Pheophytin

Dear Sir:

A discussion of several objective tests used here to measure adverse changes in frozen vegetables, including conversion of chlorophyll to pheophytin, was published earlier by Dietrich *et al.* (*Food Technol.*, **11**, 109, 1957). The chlorophyll conversion method was described by references to published literature, which gave rise to a number of requests for a detailed description of the procedure. Our intention was to publish details in later reports concerned with the measurement, but because the requests are continuing it seems appropriate to provide details to your readers now.

The method for determining the conversion of chlorophyll to pheophytin is a modification of the extraction procedure of Dutton, Bailey, and Kohake (*Ind. Eng. Chem.*, **35**, 1173, 1943) in which the method of Mackinney and Weast (*Ind. Eng. Chem.*, **32**, 392, 1940) is used for the spectrophotometric pigment measurement. The maximum at 536 mμ and the cross-over of the chlorophyll and pheophytin curves at 559 mμ may vary slightly, and should be determined for each instrument. The band width of the spectrophotometer should not be more than 5 mμ; otherwise the spectra of decomposition products cannot be separated from that of intact chlorophyll.

Procedure and calculation of results are: Blend 130 g. of frozen product with 100 ml. of acetone (technical) for 3 minutes. Weigh 80 g. of the resultant slurry into a 600-ml. beaker. Add 300 ml. of acetone and stir for 3 minutes. Add 2 to 3 g. of analytical filter aid, stir an additional 30 seconds, and filter through a 7-cm. medium (M) fritted glass funnel with the aid of light suction. The first part of the filtrate may be cloudy. When filtrate runs clear, return cloudy portion to the beaker and rerun through the filter. Do not allow the filter cake to run dry until after the final washing. Wash the paste of insoluble solids in the funnel two successive times with 50-ml. portions of acetone. Finally, apply strong suction until most of the liquid has been removed from the insoluble solids. The filtrate must be brilliantly clear. Transfer to a 500-ml. volumetric flask and make up to volume with 80% acetone (v/v). If the addition of 80% acetone causes turbidity, carefully increase the acetone concentration by adding 100% acetone until the extract is clear. Keep the solution in a cool, dark place until the spectrophotometric readings are to be made.

When raw or underblanched materials are used, it is necessary to add acetone in sufficient concentration to inhibit enzyme activity (Dietrich *et al.*, *Food Research*, 20, 480, 1955). In general, the acetone concentration in the blend should be 80% or above. As an example, 100 g. of raw green beans are blended with 500 ml. of acetone. Two hundred and fifty grams of this slurry are taken and carried through the filtration and subsequent procedures.

Optical densities (OD) of the solution, contained in cells 5 cm. in length with optically plane surfaces, are determined at two wave lengths with a suitable spectrophotometer. Zero adjustments are made with 90% acetone in the reference cell. The measurements reported previously were made at 534 and 556 mμ with a Beckman Model DU instrument [a] in a suitable range (0.2 to 0.8) of OD. Although a change in concentration of the extract changes the concentration of chlorophyll present, it does not change the ratio of chlorophyll to pheophytin.

To calculate the percentage conversion, it is necessary to determine the ratios of OD readings found at 534 and 556 mμ for chlorophyll with zero conversion (R_0), for the unknown sample (R_x), and for an extract where the chlorophyll is 100% converted to pheophytin (R_{100}).

An extract from either raw or blanched material can be treated with acid to produce 100% conversion. Add 1 ml. of a saturated solution of oxalic acid in 90% acetone to 100 ml. of the chlorophyll extract and allow to stand 22 to 24 hours and then read the OD. An alternate method is to add 3 or 4 ml. of saturated oxalic acid per 100 ml. of extract, mix thoroughly, and read new aliquots of the converted extract at ½-hour intervals over a period of ½ to 4 hours to determine the maximum conversion (a maximum OD reading at 534 mμ without an increase in OD reading of more than 0.005 at 556 mμ). The ratio of the reading at 534 mμ divided by the reading at 556 mμ for a converted extract (R_{100}) should fall in the range 2.2 to 2.4. Several samples are run and the average ratio is used in the calculation of percentage conversion. Ratios may vary with different commodities.

Calculations are made by the formula:

$$\text{Per cent conversion} = \frac{R_x - R_0}{R_{100} - R_0} \times 100$$

$$\text{for example, } \frac{1.224 - 0.900}{2.260 - 0.900} \times 100 = 23.8\%$$

where R_0 = ratio of OD readings 534/556 for zero conversion,

R_{100} = ratio of OD readings 534/556 for 100% conversion,

R_x = ratio of OD readings 534/556 for the unknown.

W. C. Dietrich
U. S. Department of Agriculture
Western Utilization Research and Development Division
Agricultural Research Service
Albany 10, California

[a] Recommendation over other instruments is not implied.

THE "NO EFFECT" LEVEL

A more basic objection to the chronic feeding study is that it is logically impossible to prove a negative. By increasingly sensitive methods we are trying to measure threshold effects, and once we succeed in measuring them we have proved there is an effect at that intake level, but we can never prove there is no effect at the next lower level. Every possible measurement can detect effects at some limiting sensitivity, but cannot prove an effect is absent at an intensity below the sensitivity. No possible set of direct observations can ever define a true "no effect" level. Frazer's discussion of safety evaluation *(4)* avoids this trap by basing the acceptable dietary level upon an effective dosage which can be determined experimentally, not upon the indeterminable highest ineffective level as we now do.

Other sciences are faced with the problem of estimating the ordinate at which a variable assumes some infinitesimal value approximating zero. They apply the concept of limits. They make measurements in the range where the variable is finite, where their techniques allow it to be estimated with the desired accuracy. Having deduced the regular relationship between the ordinate and the value of the variable, they extrapolate to zero. In the language of pharmacology, they extrapolate the dosage-response curve to zero effect. Only toxicology has trapped itself in the position where it has to attempt to measure zero.

We are in this morass because of our own default. Twenty years ago when we first detected the revolution which food technology was to undergo, we did not start to lay the groundwork for a logical proof of safety. The pressure for a multitude of decisions on safety has led administrative agencies to rely upon the persuasive, but unsound, thesis that one can determine a "no effect" level for rats, and that the susceptibility of a rat during its life-time is equivalent to that of the human during his life-time. Knowing full well that this thesis is untrue, we have all applied a very large safety factor in predicting the safe human intake. It seems that no harm has been done, but it is unsound to hide our eyes from the logical fallacy of our pragmatic course.

One component of our large safety factor is built into the units in which we express results, and hence is usually lost sight of. Equally sensitive tissues are injured by equal concentrations in the body fluids which bathe them. Equal concentrations result from equal dosages in grams per kilo body weight. If rat and man are equally sensitive, they can each tolerate without effect the same grams per kilo per day intake. When we pass from the rat "no effect" dose to the human "safe dose" we speak of p.p.m. in the diet of each. The calorific needs of small animals, due to the surface volume ratio of their bodies, are greater than those of large animals in terms of body weight. They eat more. One p.p.m. in the rat diet gives a grams per kilo intake of 2 to 5 times as much as one p.p.m. in the human diet. This ratio is implicit in our passage from rat to man, without being recognized as a component of the safety factor we discuss. It is over and above the 100-fold safety factor which we practice.

A RATIONAL ALTERNATIVE

It is useful to speculate about how we would approach the evaluation of safety were we to undertake it as a new field of inquiry, unhampered by existing precedents, controversy, and emotion. I believe we would plan work along the lines advocated by Barnes and Denz *(1)*. We would emphasize more than we do today the fact that every action of a compound is related to intake, both in intensity and in frequency of occurrence among a randomly selected population. The dosage-response curve would be a more real concept to us when we thought of chronic toxicity than it now is. With the usual experimental animals we would elucidate the characteristic physiological, biochemical and pathological actions of a compound, including the increase in effect which may accompany repetition of dosing. We would inquire whether these actions are similar for different species. We would determine a dosage-response curve for each action. At some low level of intensity almost any adverse action is transient and reversible, and hence can safely be produced experimentally in humans. If cancer is at issue, which we do not care to induce in humans, we would accept the animal curve without confirmation. For other actions we would induce the effect in humans at one or more low dosages, to determine relative species susceptibility. Then we would extrapolate the dosage-response curve to some low level of probable frequency, which informed opinion agreed corresponds to practical safety. This would define rather well the safe human intake of the additive, and comparison with the proposed intake would indicate safety or hazard of the proposal. This program would require profound thought and wide knowledge, unlike today's program, but the actual work might be completed in a rather brief period.

Following a decision that a proposal would be safe to carry out, I think we would often provide for trial usage in a restricted area. The period of the trial would be varied to accord with the nature of an effect which excessive intake might produce. Some degree of clinical check upon health would be provided in the area of trial usage. If this trial period should prove consumer acceptance, utility of the additive, and presumptive confirmation of safety, general use might follow.

Some will object that we should not rely upon experimental animals at all, partly from their belief that we have no ethical right to use another species for our own ends, partly that we are never absolutely certain that animal reactions predict human reactions. It is a waste of time to speculate upon a purely human safety evaluation. I am convinced that we will never want to base evaluation solely upon human trials. To be fully satisfactory such trials would require that humans be intentionally injured. Public enlightenment and private conscience would never permit this. We will never escape from some uncertainties about species differences. We can only reduce these by a positive experimental approach; we cannot eliminate them.

PUBLIC SCRUTINY

It is not enough that regulatory agencies should be convinced of the safety of a proposal to use an additive. The food processor himself has a major stake in the question of safety. He is responsible for the safety of his product. Reliance on private and public declarations by some authority is not an adequate defense, should some consumer claim injury. He must satisfy himself of the safety of what he proposes to do, and no legislation can remove that responsibility. He can do this only by examining carefully the bases upon which safety was evaluated, confirming by his own experiments any parts of the basis of which he himself is in doubt.

It is not only the food processor who should scrutinize the bases for a conclusion of safety of a proposed use of an additive. There are thousands of people who have some responsibility for preserving the public health, and other thousands with specialized knowledge which may be related to the question of safety. Each one of these should have an opportunity to bring his knowledge to bear in judging the soundness of a decision of safety. Only scrutiny by the entire scientific community can be relied upon to fill possible gaps in the knowledge of any individual, and to assure fully informed proper decisions which can influence the safety of our diet. I believe that no additive should reach the general food supply until the proof of safety of its use has been published for study by everyone competent to judge the soundness of the decision to use it.

SPECULATION

I conclude in a speculative vein. The open thermodynamic system which we call life must have arisen in a somewhat unfavorable environment. A limited homeostatic ability is characteristic of an open system. This ability has become more puissant as it has overcome an increasing variety of factors along the path of evolution. A generation ago Ellsworth Huntington pointed out that great civilizations have arisen only where meteorological conditions produce a constantly fluctuating temperature and atmospheric violence. More recently Arnold Toynbee has shown in more detail that every dominant culture has developed where a sufficient but not overwhelming challenge to success existed from the environment, or from the neighbors. Every toxicologist who has administered an extended series of subacute or chronic dosages to animals has found a similar result. Often a certain dosage results in animals inferior to his control animals, while some lower dosage results in animals better than his controls. I first found this many years ago with rats inhaling carbon tetrachloride vapors. Those breathing 50 p.p.m. were healthier, grew better and had more offspring than those inhaling no vapors *(7)*.

Such findings are too frequent in toxicological studies to result from the chance selection of inferior animals for the control group. They seem to be a manifestation of a general rule. Life seems to thrive upon frequent operation of its homeostatic protective mechanisms, so long as the challenge is not great enough to overwhelm the defenses. Are we truly serving public health by trying to prevent ingestion of all compounds capable of causing an adverse effect? Perhaps the traces of harmful materials inevitably present in the purest obtainable foodstuffs are enough to give the sufficient challenge to our defense mechanisms which we seem to require for abounding health. Perhaps the current better growth and improved health is partly due to the sufficient challenge to homeostasis of the traces of industrial products we receive every day. Is it possible that nutritionists will soon be advocating the controlled addition of substances to our food to replace the challenge which our ancestors received from the waste products of microorganisms, and which we now exclude by modern sanitation and packaging?

SUMMARY

In summary, we have today a widely followed and well-defined experimental technique for evaluating safety. It suffers from the necessity that we attempt the logically impossible task of proving a negative, and it does not necessarily determine any important qualitative fact about the potentially injurious action of an additive. We attempt to compensate for the shortcomings of the technique, and for ignorance, by the use of a variable arbitrary safety factor. It is possible to plan a rational approach to safety evaluation consisting of experimental studies which can yield positive information, more valid in both a qualitative and quantitative sense than our present procedures. At the very least, we should provide for scrutiny by the entire scientific community of the bases for all decisions, to allow greater confidence in protection of public health.

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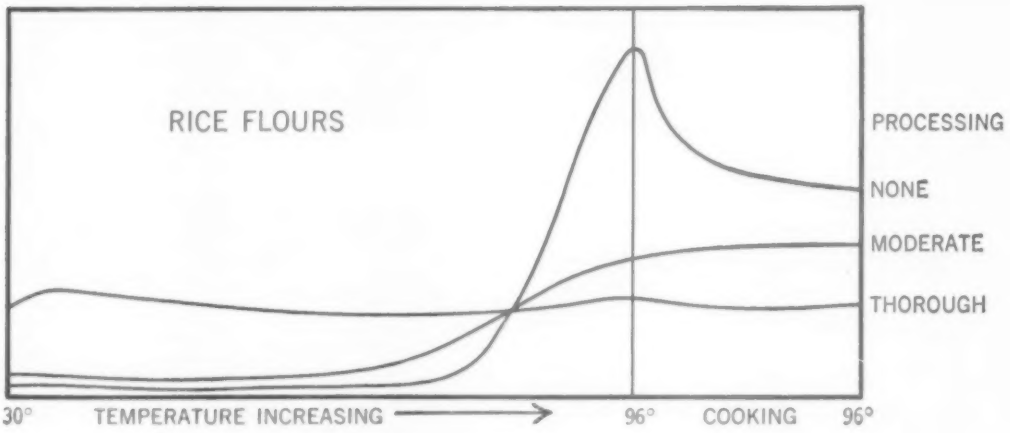

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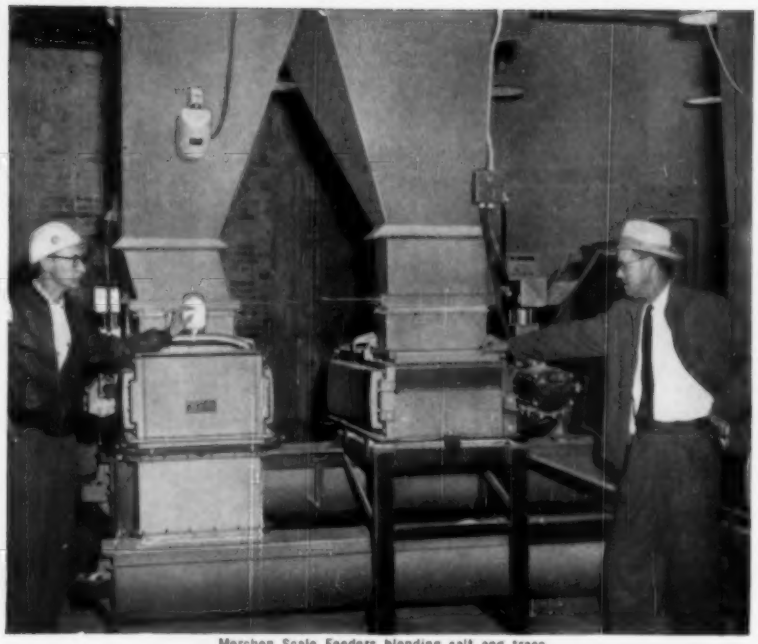

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BOOKS

BIOLOGIA ET INDUSTRIA I, ed. W. Roman. Dr. W. Junk, Publ., The Hague; Academic Press Inc., Publ. New York, 1957. 246 pp.

This book, edited by W. Roman, is the first of a series of monographs intended to form a link between the biological sciences and the various industries based on biology. This volume deals with "yeasts" and covers bakers yeast, brewers yeast, wine and fruit yeasts, Sake and similar yeasts, food and fodder yeast and yeast preparations. The contributions are by various authors. Each subject includes biological, biochemical, and technological aspects. This is an unfortunate approach since there is a great deal of duplication in the text. The introduction is quite disappointing, indicating a limited knowledge of yeasts. Unfortunately, the book also contains numerous misspellings, errors, inaccurate statements and even (at the top of page 108) the omission of one or more lines of text.

The quality of the different sections varies from an excellent and thoroughly documented chapter on brewers yeast by Thorne (596 references) to a sketchy personalized account of wine yeasts by Schanderl (12 references), in which one finds such statements as this, that culture media do not require addition of nitrogenous substances since wine yeasts are able to assimilate molecular nitrogen directly from the air. Schanderl has disregarded work done outside the Geisenheim Institute. The chapter by Arima on sake production is worthwhile, since little has been written on this subject in Western languages. Thaysen has given a rather complete coverage of food and fodder yeast production in various countries and the article contains a number of line drawings of industrial equipment. This chapter is followed by a discussion of various medicinal, nutritional and technical yeast preparations by Pyke—who also covers the cultural aspects of bakers yeast. The biology, biochemistry, and physiology of bakers yeast is treated quite well

by Nickerson and Schulz, although this reviewer would like to have seen a more thorough discussion of yeast respiration. Instead this subject is covered briefly by Thorne under brewers yeast.

Most of the chapters contain few if any references beyond 1952. This reviewer would recommend the book only to experienced scientific readers who would want information in fields related to their own area of specialization. Unfortunately, the volume contains too many errors to permit its use as an authoritative reference work for non-critical readers.

H. J. Phaff
Davis, California

Light, Vegetation and Chlorophyll. J. Terrien, G. Truffaut, and J. Carles. Translated by Madge E. Thompson. Philosophical Library, Inc. New York, 1957. 228 pp.

This book is a translation of the books Lumière et Végétation by Jean Terrien and Georges Truffaut and L'Énergie Chlorophyllienne, by Jules Carles. Only needless duplication was eliminated. It is unfortunate, however, that nowhere in the volume is mention made of the fact that these books were published in Paris in 1951 and 1953, respectively. This explains the fact that the material worked out since these dates is missing.

The book is made up of two parts, the first, Light and Vegetation, is divided into eleven chapters. These chapters cover among other things, the roles of the different types of radiation, including infra-red and ultra-violet, as well as visible light, photosynthesis, and analogies of photography with photosynthesis. Included is a page of conclusions.

The second part, Chlorophyll and Energy, is divided into five chapters. The topics discussed include the chemical properties of chlorophyll, its synthesis and disappearance, and its action. These are followed by a chapter on the chemistry of photosynthesis (up to the dates the original books were written), followed by one on assimilation which includes the effects of temperature, and the efficiency of the reaction.

This book is one which perhaps should be in the library of anyone interested in fruits and vegetables, as well as in plant science.

Frank A. Lee
Geneva, New York

Laboratoriumsbuch für den Lebensmittelchemiker (Laboratory Manual for the Food Chemist). By the late A. Beythien, revised by W. Diemoir in collaboration with six others. 7th edition. Verlag von Theodor Steinkopf Dresden and Leipzig, 1957, xxi + 723 p.

This is the seventh edition of a text and reference work first published in Germany in 1930. The sixth edition was the last revision made by A. Beythien. The first 105 pages describe general chemical and physico-chemical methods and the remainder deal with analytical methods useful in the meat and meat products industry (44 pages), fish and sea food products (4 pages), eggs (9 pages), milk and dairy products (45 pages), oils and fats (68 pages), cereal products (41 pages), fruit and vegetable products (70 pages), sugar and honey (24 pages), alcoholic beverages (62 pages), vinegar (9 pages), coffee, tea, cocoa and miscellaneous products (49 pages), thickening agents (15 pages). Water, chemical additives, and naturally occurring toxic compounds are included in the remaining 105 pages. The methods described apparently are those used in Germany only, for references to literature other than to German publications are very limited. In the list of abbreviations the Official Methods of Analysis of the A.O.A.C. is cited but this is not referred to in the text. The references cited in the footnotes occasionally refer to an article published as late as 1952 but for the most part are to older literature. This text will be useful to food technologists, capable of reading German, largely as a guide to methods of analysis used in Germany for various types of foods and adjuncts.

M. A. Joslyn
Berkeley, California

LITERATURE OF FOOD RESEARCH AND TECHNOLOGY [1]

Commodities

Aeration of wheat in prolonged storage for quality control. H. H. DeLong. College Station, Brookings, S. D., 1958. 36 p. (South Dakota Agricultural Experiment Station. Technical bulletin 19.) pap. apply.

Critical data tables, 2nd ed., Comp. by Geo. E. Carson. Washington 6, D. C., Corn Industries Research Foundation, 1001 Connecticut Ave., N.W., 1957. 452 p. loose leaf.

Critical tables on corn sirups, sugar, dextrose and sucrose, factors, corrections and common tables, etc. A new edition of a very useful reference tool.

United States standards for grades of frozen sweet cherries, effective Mar. 1, 1958. Washington, U. S. Department of Agriculture, 1958. 5 p. processed. pap. apply.

Also published in *Federal Register,* January 29, 1958. Supersedes standards in effect since June 1, 1946.

Chemical Aspects

Advances in protein chemistry, v. XII. New York, Academic Press, 1957. 687 p. $12.00.

A new volume of a standard series.

General biochemistry, 2nd ed. Joseph S. Fruton and Sofia Simmonds. New York, John Wiley, 1958. 1089 p. $18.00.

First edition published in 1953.

Introduction to protein chemistry. Sidney W. Fox and Joseph F. Foster. London, Chapman and Hall, 1957. 76 s.

About one third of the book is devoted to amino acids and the peptides.

The lipids, their chemistry and biochemistry. v. 3. Harry J. Deuel, jr. New York, Interscience, 1957. 1103 p.

V. 3 covers biochemistry, biosynthesis, oxidation, metabolism and nutritional value.

A manual of paper chromatography and paper electrophoresis. 2nd ed. enl. Richard J. Block, Emmett L. Durrum and Gunter Zweig. New York, Academic Press, 1958. 722 p. $12.50.

A practical manual, first issued in 1955. A very long bibliography.

Reports on the progress of applied chemistry. v. 41, 1956. London, Society of Chemical Industry, 1958. 791 p. 100 s.

Biological Aspects

CIBA Foundation symposium on the chemistry and biology of mucopolysac-

[1] Material for this list should be sent to Dr. James G. Hodgson, Chief, Library Branch, Quartermaster Food and Container Institute for the Armed Forces, 1819 W. Pershing Road, Chicago 9, Illinois.

charides. Ed. by G. E. W. Wolstenholme and Maeve O'Connor. Boston, Little, Brown and Co., 1958. 323 p. $8.50.

Issued in London by J. & A. Churchill. p. v. "There was some skirmishing on the definition of the word 'mucopolysaccharides' but it was decided for the conference and this volume to go ahead on the broad understanding that the term denoted carbohydrate-amino acid complexes which cannot yet be described in agreed exact terms."

Handbook of basic microtechnique. 2nd ed. Peter Gray. New York, McGraw-Hill, 1958. 261 p. $6.00.

First issued in 1952. New addition contains added material on the microscope and elementary photomicrography.

Nutrition

A history of public health. George Rosen. New York, MD Publications, Inc., 1958. 531 p. (MD monographs on medical history, v. 1.) $5.75.

Author is Professor of Health Education at Columbia. As part of the section "Biological era and aftermath," p. 404–119 deals with the "Rise of scientific nutrition," and indicates the close relationship of nutrition to public health.

Miscellaneous

The effect of varying the gap between the outer flaps of corrugated boxes for canned goods. New York, Container Laboratories, 1958. 27 p. processed. Apply.

Prepared for the Fibre Box Association, 224 South Michigan Ave., Chicago 4, Illinois. Damage increased as the gaps were enlarged.

International Basic Economy Corporation. IBEC 1957 annual report. New York, 20, The Corporation, 30 Rockefeller Plaza, 1958. 16 p.

Reports on current progress of food distribution, milk, soluable coffee, and agricultural products in projects mostly in South America.

Russian Titles

[*Action of ionizing radiation on meat.*] G. Egiazarov. Miasnaia industriia SSSR [Meat Industry of the U.S.S.R.] 28(6): 51–53, 1957.

[*Biochemistry of meat.*] Biokhimiia miass. N. N. Krylova and IU. N. Liaskovskaia. Moskova, Pishchepromizdat, 1957. 370 p.

[*Development of the production of food concentrates in the Soviet Union.*] I. N. Vol'per. Konservnia i ovoshchesushil'naia promyshlennost' [The Canning and Dehydrated Vegetables Industry], 12(10): 45–47, October 1957.

[*Effect of high elevations on vitamin B_1 and B_2 metabolism in the human body.*] IU. F. Adalov. Voenno-meditsinskii zhurnal [Journal of Military Medicine], no. 7: 78–80, July 1957.

[*Effect of magnesium and calcium salts on the brine microflora.*] A. M. Teplitskaia. Vladivostok. Tikhookeanskii nauchno-issledovatel'skii institut rybnogo khoziaistva i okeanografii. Izvestiia. [Pacific Ocean Scientific Research Institute of Fisheries and Oceanography. Bulletin.] 44: 171–178, 1957.

[*Effects of different rations on the mineral and vitamin composition of blood and milk in ruminants.*] Summary in English. H. I. Kisel'ov. Ukrainskii khimicheskii zhurnal. [Ukrainian Biochemical Journal.] 29 (4): 486–493, 1957.

[*Microbiology of milk and milk products.*] Mikrobiologiia molaka i molochnikh produktov. Moskva, Pishchepromizdat, 1957. 433 p.

[*Refractory determination of the fat content of food concentrates.*] L. M. Kalashnikov, O. L. Babicheva. Konservniia i ovoshchesushil'naia promyshlennost' [The Canning and Dehydrated Vegetables Industry], 12(12): 38–40, December 1957.

[Sugar modification products and their effect on the properties of the caramel mass.] A. L. Sokolovskii, V. N. Nikiforovn. Zhurnal prikladnoi khimii. Journal of Applied Chemistry], 30(8): 1261–1263, August 1957.

[*Using sodium amytal and caffeine in reactive states characterized by refusal of food.*] GU Sarafian. Zhurnal nervopatologii i psikhiatrii [Journal of Neuropathology and Psychiatry], supplement: 92–93, 1957.

[X-ray defectoscope for the inspection of sausage products.] M. Brzhostovskii, E. Mieserov. Miasnaia industriia SSSR [Meat Industry of the U. S. S. R.], 28(5): 32–33, 1957.

ABSTRACTS

—Compiled by H. A. Campbell

ANALYTICAL METHODS

Quantitative determination of hydroxyproline by paper chromatography.

ROBERTS, H. R. AND KOLOB, M. G. (Natl. Dairy Products Corp., Oakdale, Long Island, N. Y.). *Nature 181,* 837 (1958).

In addition to a marked improvement in the accuracy and precision of the analysis, the use of the new ninhydrin-isatin-triethylamine reagents offers a number of distinct advantages. It is specific for hyroxyproline. It is more sensitive than isatin. The concn. of the standard and unknown solns. spotted on the filter paper is one-half the concn. required when using isatin. The max. densities of the hydroxyproline spots are greater and can be read immediately after color development, thus eliminating the 24-hr. color development period necessary when using isatin.

A micro-electrophoretic method.

KOHN, J. (Queen Mary's Hosp., London, Engl.). *Nature 181,* 839–40 (1958).

A micro-electrophoretic technique is described which is sensitive, simple and rapid and does not require any elaborate app. Very clear results can be obtained with samples of the order of fractions of a μl. with a protein content of 10 μg. and even less. The technique is a combination of the membrane filter electrophoresis and, in particular, of the small-scale technique, with the use of a very sensitive stain—'Nigrosin'.

BIOLOGICAL SCIENCES

Biochemistry

The mechanism of carbohydrase action. 4. The mechanism of α-enzyme action.

WALKER, G. J. AND WHELAN, W. J. (The Lister Inst., London, Engl.). *Biochem. J. 67,* 548–51 (1957).

The reaction between starch and glucose, catalyzed by α-enzyme, is a convenient means of prepg. maltodextrins. The proof of the position of radioactive labeling in the maltodextrins has enabled a precise formulation to be given to the manner in which α-enzyme transfers glycosyl radicals between donor and acceptor substrates. An unidentified disaccharide is a minor product of the reaction between starch, glucose and α-enzyme, and may have arisen by enzymic polymerization of glucose.

A study on the esterolytic properties of proteinases: action of papain, trypsin, and chymotrypsin.

MCDONALD, C. E. (Purdue Univ., Lafayette, Ind.). *Dissertation Abstr. 17,* 1455 (1957).

Specificity studies have been carried on with a group of esters split by both papain and trypsin. The old opinion that these enzymes are very much alike was confirmed; however, outstanding differences in the behavior of papain and trypsin were discovered.

Microbiology

A comparative evaluation of methods for determining the bacterial contamination of surfaces.

ANGELOTTI, R., FOTER, M. J., BUSCH, K. A. AND LEWIS, K. H. (Public Health Service, Cincinnati, Ohio). *Food Research 23,* 175–84 (1958).

The surface rinse-agar plate count, surface rinse-membrane filter count and the APHA cotton swab methods yielded high av. percent recoveries with fairly good precision. The cotton and alginate swab methods gave low av. percent re-

coveries but excellent precision. Variable of type, distribution, no. of organisms present and the manner in which the procedures are applied significantly affect the results obtained.

Nutrition

Measurement of energy content of foodstuffs.

Nutrition Revs. 16, 51–2 (1958).

A simple and reproducible method for detg. the energy content of foods based on the concept that animals consuming adequate amts. of all essential dietary constituents, except calories, should gain wt. in proportion to the no. of calories ingested has been devised. This method provides a rapid and simple method of estg. the available energy content of foods and obviates the need for detg. digestibility, body storage and excretion of endogenous material. It provides a means of detecting changes in nutritive value relating to fat, protein or carbohydrate.

Nutritive value of proteins.

Nutrition Revs. 16, 56–8 (1958).

Recent studies have critically evaluated the method of measuring the nutritive value of protein in terms of protein efficiency. Among the criticisms of this method is failure of many investigators to find the dietary level of a given protein that would yield maximum protein efficiency (max. gain of protein consumed). Protein efficiency ratios vary depending upon the feeding period and may account for variable results in the literature. It has also been found that in general protein efficiency ratios decrease with increasing concns. of protein in the ration.

Relation of climate and temperature to food and water intake in man.

Welch, B. E., Buskirk, E. R. and Iampietro, P. F. *Metabolism 7*, 141–7 (1958).

The calorie intake of men doing moderate work was studied in 3 different climates. The results indicate that calorie intake was the same in all climates when calcd. on the basis of body wt. and that there was no relationhsip between temp. *per se* and calorie intake. Water intakes were shown to be essentially the same in the temp. range −20 to +60° F., but increased sharply at temps. above 60° F. due to increased sweating.

Nutritional research in atherosclerosis—A progress report.

Van Itallie, T. B. (Dept. of Nutrition, Harvard School of Public Health, Boston). *J. Am. Dietetic Assoc. 34*, 248–53 (1958).

Formula diets and "low-fat" diets, supplemented with certain vegetable oils can lower serum cholesterol levels. Such

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diets act by promoting increased excretion of cholesterol and its end products in the feces. The preliminary clinical results obtained with cholesterol-lowering diets in patients with atherosclerotic heart disease are too limited and uncontrolled to interpret at this time. Nevertheless, the use of such diets seems warranted in selected cases since there are theoretical grounds for believing that clinical benefits may ensue.

Arteriosclerosis, especially of the coronary vessels, during childhood.

JANSSEN, W. Monatsschr. Kinderh. *105*, 361–6 (1957); *J. Am. Med. Assoc. 166*, 696–7 (1958).

Studies concerned particularly with the coronary arteries in arteriosclerosis indicated not only an over-all increase in coronary sclerosis during recent decades but also its occurrence at earlier times. In this connection, the author mentions cases of so-called malignant juvenile sclerosis, with protein-rich intimal edema and swelling necrosis. He raises the question of whether the edematous intimal swelling represents a specific morphological characteristic of juvenile coronary sclerosis or whether they represent the initial stage of arteriosclerosis.

Deficiences in the lipoprotein lipase system in atherosclerosis.

PILGERAM, L. O. (Dept. of Chem., Stanford Univ., Calif.). *J. Gerontol. 13*, 32–42 (1958).

A significant deficiency of cofactor activity in the lipoprotein lipase system has been found in the plasma of atherosclerosis patients. Preliminary expts. suggested that a part of the deficiency represents inadequate activation of lipid by protein and that a relationship exists between the activity levels of cofactor and the onset of myocardial infarction.

Essential fatty acids, lipid metabolism, and atherosclerosis.

KINSELL, L. W., MICHAELS, G. D., FRISKEY, R. W. AND SPLITTER, S. (Highland Alameda County Hosp., Oakland, Calif.). *Lancet 7016*, 334–9 (1958).

The addn. of purified ethyl and glycerol esters of linoleic acid to the diet lowers the plasma-lipid levels in healthy and in unhealthy people. The addn. of oleic-acid prepns. does not do this. On the basis of these and earlier observations it can be concluded that the major active ingredient in various vegetable fats responsible for lowering the plasma cholesterol is linoleic acid. Evidence is presented that the prescription of a low-fat diet is biologically unsound.

Cholesterol in diet and serum.

Nutritional Revs. 16, 42–4 (1958).

Studies with human subjects support the view that endogenous synthesis of cholesterol is the primary factor in human regulation of the concn. of this substance in the blood. As indicated by various expts. with animals, the liver probably is inhibited to the proper degree in its synthesis of cholesterol when this is present in the circulation by virtue of the diet.

Effect of linolenic and stearic acids on cholesterol-induced lipoid deposition in human aortic cells in tissue-culture.

RUTSTEIN, D. D., INGENITO, E. F., CRAIG, J. M., MARTINELLI, M. AND FOLEY, M. L. (Harvard Univ. Med. School, Boston, Mass.). *Lancet 7020*, 545–52 (1958).

In tissue cultures of human aortic cells, deposition of lipoid can be induced by cholesterol, is reversible, can be inhibited by unsatd. fatty acid (linolenic acid), and can be potentiated by the corres. satd. fatty acid (stearic acid).

Inhibitors of cholesterol biosynthesis.

Nutrition Revs. 15, 309–11 (1957).

Endogenous synthesis normally adds considerably more cholesterol to the body pools than does the diet. Several steroids fed in large doses depressed the incorporation of acetate into liver cholesterol in rats. One steroid, namely, 4-cholestenone can not apparently be converted to cholesterol and may act as an analog of cholesterol in the later stages of cholesterol synthesis, thus inhibiting reactions somewhere between squalene and cholesterol. The serum cholesterol level of animals fed 1% 4-cholestenone was 44% below that of control animals but caused severe hypertrophy of the adrenals and 22% deaths after 8 weeks on test. Later preliminary studies with rats fed smaller amts. of 4-cholestenone indicate that blood cholesterol may be reduced without impairing growth or causing adrenal hypertrophy.

Adult scurvy.

CUTFORTH, R. H. (King's Coll. Hosp. Med. School, London, Engl.). *Lancet 7018*, 454–8 (1958).

In 1951–57 11 patients with scurvy were found in Engl., each of whom was living on a diet deficient in vitamin C. The cases fell into 3 groups: elderly men living alone; those dieting because of medical advice; and the "food crank." The chief symptoms were pain, lethargy, anorexia, and mental depression. The chief signs were small bruises on the limbs, extravasation of blood into the tissues, and anemia. Typical scorbutic lesions of the gums were seen in only 1 patient, but only 4 patients had any teeth. The symptoms and signs, including anemia, responded promptly to ascorbic acid.

Chelate iron therapy.

FRANKLIN, M., ROHSE, W. G., DE LA HUERGA, J. AND KEMP, C. R. (Univ. of Illinois Coll. of Med., Urbana). *J. Am. Med. Assoc. 166*, 1685–93 (1958).

There is an increasing incidence of death in children after accidental ingestion of overdosages of therapeutic iron preps. The chelation of iron minimized its toxicity and provided a high factor of safety against fatal poisoning. Hemopoietic and clinical responses in humans were not impaired by the chelate binding of the iron.

Thiamine in human milk.

Nutrition Revs. 16, 44–6 (1958).

The level of certain B vitamins in human milk, especially thiamine, is known to be influenced by the dietary intake of vitamins and the stage of lactation. Evidence has been presented by several workers that the thiamine intake of many mothers and infants is extremely low, particularly in rice eating areas. There is a possible relation between this intake and beriberi in infants.

ENGINEERING RESEARCH

Guide to materials standards and specifications. Part I. Government and national standards.

KAIDANOVSKY, S. P. *Materials in Design Eng. 47*, 96–100 (Mar. 1958).

Engineering standards and specs are issued by many organizations and are published in many documents. To help engineers find and use such standards effectively, this article discusses the organizations which issue national standards on engineering materials. Federal and Military specs and standards, Commercial Standards and Simplified Practice Recommendations of the Dept. of Commerce, ASTM, SAE and ASA standards are covered.

Get parts cleaner by ultrasonics.

BRANSON, N. G. (Branson Ultrasonics). *Materials in Design Eng. 47*, 118–21 (Feb. 1958).

Advantages and limitations of high-frequency liquid-immersion cleaning are described and illustrated. Advantages noted are thoroughness, cleaning of hard-to-reach areas, and speed. Limitations are that spongy deposits are not effectively removed, cavitation erosion may occur where gas is trapped in the cleaning liquid, while complete degassing reduces cleaning effectiveness.

FOOD AND FOOD TECHNOLOGY

Baking and Bakery Products

Nutritive value of bread protein fortified with amino acids.

BENDER, A. E. (Research Dept., Boyril Ltd., London, Engl.). *Science, 127* 874–5 (1958).

In feeding expts. with bread protein that had been fortified with various amino acids, it was shown that in bread, threonine is the second limiting amino acid and that methionine is the third. A comparison was made of protein evaluations, protein efficiency ratio and the net protein utilization (NPU) or the biol. value and digestibility of bread fortified with lysine. The author suggests that availability of protein in bread can be increased with the fortification of lysine, threonine and methionine.

Baking properties of air-classified flour fractions.

Wichser, F. W. (Pillsbury Mills, Inc., Minneapolis, Minn.). *Cereal Sci. Today 3*, 123–6 (1958).

With the use of this new air-classification process the adverse influences of climate, soil, and constantly changing varieties will be substantially minimized. Moreover, the baker will be provided with a new family of flours tailored to his particular needs, with a uniformity upon which he can rely.

Cereals and Grains

Amino acid supplementation of rice.

Nutrition Revs. 16, 46–8 (1958).

Experiments were conducted feeding 4 young adult human diets in which rice was the major source of protein. Amino acid supplements were studied using nitrogen balance techniques to assess their effects. Amino acid supplements tested included L-threonine, 0.62 g. daily; L-lysine, 0.62 g.; this combination with either 1.0 g. of DL-methionine or 0.6 g. of L-histidine HCl; 2 mixts. of 8 essential amino acids to provide 0.82 or 0.92 g. of N daily; a mixt. of non-essential amino acids to provide 0.82 g. of N and a second mixt. to provide the same amt. of N as the individual supplements of lysine and threonine. No uniform pattern of response was noted. In a number of instances no response was obtained and in 2 cases adverse effects were noted when beneficial effects were expected. Effects of the amino acid supplements were made less effective than noted in animals.

Coconut

FAO group on coconut and coconut products.

Anon. *Monthly Bull., Agr. Econ. and Statistics 7*, 13–14 (Jan. 1958).

A report is given on the first annual session of the FAO Group, at which 24 governments were represented. Many aspects of coconut production were considered, including consumption and production in individual countries, world trade developments and use in such products as margarine and soap. The Group recommended a technical assistance project and established a standing subcommittee on the quality and grading of copra.

Eggs

The shell membrane as a barrier to bacterial penetration of eggs.

Kraft, A. A., Elliot, L. E. and Brant, A. W. (U. S. Dept. of Agr., Agr. Research Service, Beltsville, Md.). *Poultry Sci. 37*, 238–9 (1958).

From the data it was concluded that the membrane acts as a phys. barrier to entrance of bacteria through the shell. This may be the sole protective function of the membrane, since previous studies have eliminated its role as a bactericidal agent against several types of bacteria known to be capable of causing spoilage in shell eggs.

Fats and Oils

The determination of the available caloric content of rapeseed oil by rat growth.

Middleton, E. J. and Campbell, J. A. (Food and Drug Labs., Dept. of Natl. Health and Welfare, Ottawa, Can.). *Can. J. Biochem. Physiol. 36*, 203–8 (1958).

The available metabolic energy of rapeseed oil, semihydrogenated rapeseed oil, and corn oil was measured in terms of 7-day body-wt. gains of weanling rats fed a calorically restricted diet. Standard bio-assay procedures were used with lard as a reference standard. The oils were fed at 3 levels equiv. to 5, 9, and 17% of the diet by wt. Growth responses to the 3 oils and to lard were similar and the calcd. caloric content of the oils showed no significant difference from that of lard. A 1-week assay was as precise as a 5-week assay.

Flavors and Flavoring

Powdered liquids start revolutions.

Mooers, C. *Chemistry 31*, 1–4 (Mar. 1958).

The National Cash Co. turns liquids into powders by breaking up the liquid into microscopic droplets and then coating them with a thin layer of gelatin. Among the many uses of such powders are a "No Carbon Required" paper, a memory device in computing machines and liquid instant coffee which would retain all its odor and flavor until it was ready for use.

Investigation on aromatic substances. 2. Strawberry.

Seibel, C. F., Schinz, H. and Stoll, M. *Helv. Chim. Acta 41*, 372–7 (1958).

A short analysis of strawberry ext. has been made. Besides some compds. already mentioned by other workers, phenylethyl alcohol and *p*-hydroxyphenylethyl alcohol have been isolated.

Fruits and Vegetables

Effect of varied storage temperatures on microorganisms in frozen concentrated orange juice.

Wolford, E. R. (Fruit and Vegetable Chem. Lab., Pasadena, Calif.). *Appl. Microbiol. 6*, 139–41 (1958).

Samples of orange juice concentrate were submitted to time-temp. conditions that frozen concd. orange juice might encounter during its com. experience. Plate counts were found to decrease with time. The most rapid decreases were in samples subjected to the most severe temp. conditions—14 days at 20° F., followed by 7 days at 40° F. Average counts under this schedule showed only 2.6% survival. Coliforms were found in 4 of 5 lots at the beginning of the expt., but were practically eliminated after storage at simulated distribution patterns.

Meat and Poultry

Comparative effectiveness of feeding aureomycin and dipping in an aureomycin solution as a means of preserving poultry meat.

Anderson, G. W., Epps, N. A., Snyder, E. S. and Slinger, S. J. (Dept. of Poultry Husbandry, Ontario Agr. Coll., Guelph, Ontario, Can.). *Poultry Sci. 37*, 174–9 (1958).

Use of 10 p.p.m. of aureomycin in a dip soln. exerted a bacteriostatic effect on the microorganisms present on poultry tissue. These samples had a slightly lower bacterial count and remained fresh for a greater period of time than the untreated controls. The feeding of high levels of aureomycin for 5 days prior to slaughter was beneficial in prolonging the keeping time of poultry meat. The combination of feeding and dipping was not distinctly superior to either treatment used singly. The residual aureomycin present in the tissue after the various treatments was completely destroyed by the cooking methods employed.

Milk Technology

Rapid chemical changes in reconstituted dry milk.

Keeney, M. and Bassette, R. (Dairy Dept., Univ. of Maryland, College Park). *Science 126*, 511–12 (1957).

The results definitely indicate that some rapid chem. changes take place in the freshly reconstituted instant milks. The higher levels of 5-hydroxymethylfurfural and reductones in the instant milks, as compared with their noninstant counterparts, indicate that the instantizing process used on these milks caused browning-type reactions to take place. Certain characteristic products of the browning reaction accumulate in dehy-

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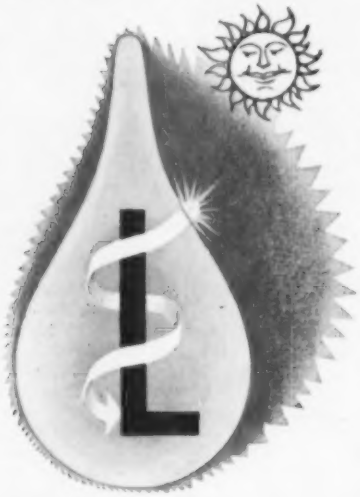

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drated foods and may be rapidly converted to other characteristic products upon hydration. The foregoing manifestation may be encountered in many other dehydrated foods.

Potatoes

Shelf life of consumer-packaged prepeeled potatoes stored at various temperatures.

ANDERSON, R. E. *Am. Potato J. 35*, 421 (1958).

Material was obtained from com. processors and repacked in perforated or nonperforated 1-pound polyethylene bags. The av. shelf life varied from 1 day at 85° to 14–15 days at 32°. At 40° the shelf life was 12 days in perforated bags but 8–9 days in nonperforated bags.

Starches

The alkaline degradation of polysaccharides. III. Action of sodium hydroxide on amylose.

MACHELL, G. AND RICHARDS, G. N. *J. Chem. Soc.* 1199–204 (1958).

The action of 0.5*N*-NaOH at 100° on amylose is of 2 main types: "degradation" producing mainly D-gluco*iso*saccharinic, formic, and lactic acid; and a "stopping" reaction affording alkali-stable amylose probably bearing terminal D-gluco*meta*saccharinic acid units. The analogy with the similar degradation of cellulose is discussed.

Separation of amylose from amylopectin of starch by an extraction-sedimentation procedure.

MONTGOMERY, E. M. AND SENTI, F. R. (Northern Utilization Research and Devel. Div., Peoria, Ill.). *J. Polymer Sci. 28*, 1–9 (1958).

Corn, wheat, and potato starch were fractionated into their amylose and amylopectin components by selective extn. of amylose in hot water after the starch had been preheated by heating in aq. mixts. of glycerol, *n*-butanol, Pentasol, Cellosolve, or dioxane. About ¾ of the amylose was leached in relatively pure form from starch in the first extn. at 98° C. The granule residue sedimented by centrifugation, was sepd. as relatively pure amylopectin after 2 or more addnl. extns. Amylose fractions isolated from successive extns. had progressively lower intrinsic viscosities and absorption coeffs. of their iodine complexes indicating that this component was subfractionated according to molecular size and/or structure.

PACKAGING

Improved packaging methods can cut insect infestation.

LAUDANI, H., DAVIS, D. F. AND SWANK, G. R. (Stored-Products Insects Lab., Savannah, Ga.). *Modern Sanit. and Bldg. Maintenance 10*, 17–21; 52 (Mar. 1958).

A review of available information on the susceptibility of various types of food packages to insect entrance and on methods of increasing their resistance.

RADIOCHEMICAL TECHNOLOGY

Barium-140 radioactivity in foods.

ANDERSON, E. C., SCHUCH, R. L., FISHER, W. R. AND VAN DILLA, M. A. (Los Alamos Sci. Lab., Univ. of California, Los Alamos, New Mex.). *Science 127*, 283–4 (1958).

Data is reported summarizing the conens. of Ba-140 in samples of powdered milk collected from different areas of the United States during nuclear weapons tests. Unlike Sr-90, Ba-140 had a very short half-life and therefore does not present a cumulative hazard.

STATISTICS

The k-visit method of consumer testing.

FERRIS, G. E. (General Foods Corp., Tarrytown, N. Y.). *Biometrics 14*, 39–49 (1958).

The method described is currently being applied in Research Center consumer tests as the "Repeated Pair" method, where 2 visits are made. The information obtained in the analysis tells the experimenter what proportion of the consumer population consistently prefer each sample and what proportion has no preference or no consistent preference.

INDUSTRY PUBLICATIONS

A new 44-page booklet on **food preparation and serving equipment** is now being distributed by Allegheny Ludlum Steel Corporation. The booklet gives detailed information on food preparation and serving equipment used in restaurants and cafeterias; hospitals and institutions; colleges and universities; clubs; stores; trains and ships; hotels and motels; employee cafeterias; diners and lunch counters; churches; and the armed forces. Almost 150 photographs appear in the booklet. The booklet includes a technical section on stainless steel as it relates to the food preparation and serving industries, and a table on the corrosion resistance of stainless steels to various media. A copy

of the booklet can be obtained by writing to the Advertising Department, Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.

The 1958 edition of the AMERICAN POTATO YEARBOOK has just come off the press. The current volume contains 80 pages packed with **information for the potato grower,** shipper, jobber, agricultural teacher, research specialist and all others connected with potatoes in any way.

A special feature is the illustrated article on Potato Washing and Waxing by Herbert Findlen, U. S. Department of Agriculture, East Grand Forks, Minn. Also of great interest are two pages of complete figures on potato acreage, yield, production, farm disposition and utilization in the U. S. from 1919 to 1956. There is in addition a current list of recent references to potato culture in the U. S. and Canada, comprehensive information on United States Standards for Potatoes and complete details on leading potato producing areas. Other interesting items include rules and regulations affecting the shipment of seed potatoes, 1958 acreage guides, a list of leading United States and Canadian associations engaged in the improvement of potatoes, together with the names of United States and Canadian seed certification officials. The YEARBOOK also gives information on how and where to secure helpful brochures and leaflets covering all phases of the potato industry. Copies of the YEARBOOK may be secured from the AMERICAN POTATO YEARBOOK, 8 Elm Street, Westfield, New Jersey.

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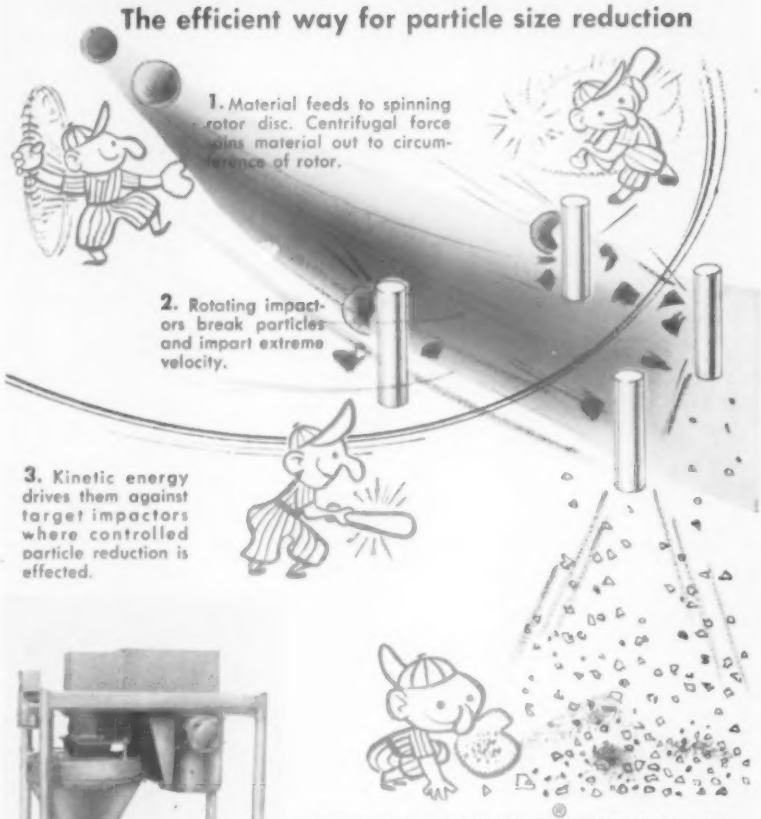
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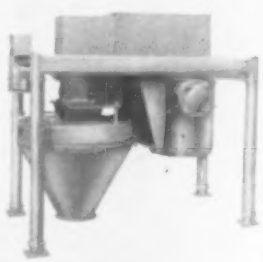

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search literature in succinct "capsule" form. Currently available by application to the Foundation is "Immersion Crusting (Freezing) of Poultry," a discussion of this technique by Dr. Wm. Stadelman of Purdue University and others as presented at the Dallas meeting of the Foundation.

A four page bulletin describing food uses for **3,3'-Thiodipropionic Acid** is available from American Cyanamid Company. This antioxidant is being offered in experimental quantities by the Food Industry Development Section of the Agricultural Division, P. O. Box 383, Princeton, New Jersey.

PERSONNEL

Marcel Gagnon

The appointment of **Dr. Marcel Gagnon,** IFT member, as Production Manager and Director of Research and Development of Alphonse Raymond Limited, Montreal, has been announced by Mr. Jean Raymond, Q.C., President. Dr. Marcel Gagnon was a member of the Faculty of the University of Massachusetts where he directed a U.S. Army Research contract as assistant-professor in the Department of Food Technology.

The promotion of three H. Kohnstamm & Co., Inc., chemists to executive posts has recently been announced. **Dr. Samuel Zuckerman,** plant superintendent in Brooklyn, has been named a vice president. **Dr. David Jorysch,** technical director of the flavor department and a member of IFT, and **Dr. Robert Cooney,** a research supervisor, have been appointed assistant vice presidents.

Dr. Ferdinand P. Mehrlich, recently appointed Scientific Director of the U. S. Army Quartermaster Food and Container Institute for the Armed Forces, Chicago, Ill., has actively taken over direction of the technical program of the Institute. Foods and packaging for simplified feeding systems, radiation preservation of foods, and the development of functional packaging for Armed Forces' use are among the many investigations to which Dr. Mehrlich and his staff will give guidance.

F. P. Mehrlich

Headquarters of the QmFCI, AF is the Quartermaster Research and Engineering Command, Natick, Massachusetts. Colonel Ervin L. Keener is Commandant of the Institute. Dr. Mehrlich succeeds Dr. Donald K. Tressler, who retired early in 1958.

From September 1955 until he joined the Institute staff, Dr. Mehrlich was engaged as a consultant for various organizations including: General Foods Corp., Arthur D. Little, Inc., National Planning Association, and the Cocoa Research Institute. He was vice president, trustee, and director of research of the International Basic Economy Corporation Research Institute, New York, from August 1949 to July 1956; assistant vice president in charge of research and a member of the executive committee of Hawaiian Pineapple Company, Ltd., Honolulu, from April 1935 to August 1949; and associate pathologist, Pineapple Research Institute, Honolulu, from August 1930 to April 1935.

A native of Cincinnati, Ohio, Dr. Mehrlich received an A.B. degree (magna cum laude) from Butler University, Indianapolis, Indiana. He received his doctorate from the University of Wisconsin, where he pursued research studies in plant physiology and pathology. Dr. Mehrlich has published widely on these and other food-related subjects, and has been active in the professional societies including the Institute of Food Technologists.

Harold J. Humphrey, a charter member of IFT, and former research manager for the Birds Eye division of General Foods Corp., has been appointed to the newly created position of corporate research consultant. He has been associated with GF's Birds Eye division and its predecessor company since 1926. He supervised one of the first frozen food packs and, since then, has held a succession of important technical posts in Birds Eye.

In his new capacity, Mr. Humphrey will be closely associated with GF's new products and pioneering research program. He is being succeeded by **Dr. Kenneth Dykstra,** also an IFT member. Dr. Dykstra has been with GF since 1943, most recently as manager of the Birds Eye division laboratory at Albion, N. Y.

Clarence K. Wiesman, general manager of quality control and food research at Armour and Company, was elected president of Research and Development Associates Food and Container Institute at their recent convention in Chicago.

C. K. Wiesman

Dr. William B. Bradley, American Institute of Baking, was elected chairman of the board; C. G. Harrel of Pillsbury Mills, Inc., vice chairman; Weld Conley, Chain Belt Company, executive vice president; C. F. Evers, Ac'cent-International, vice president in charge of activities; Joseph Czarnecki, Griffiths Laboratories, treasurer; and Col. R. A. Isker, U. S. Army, Ret., secretary.

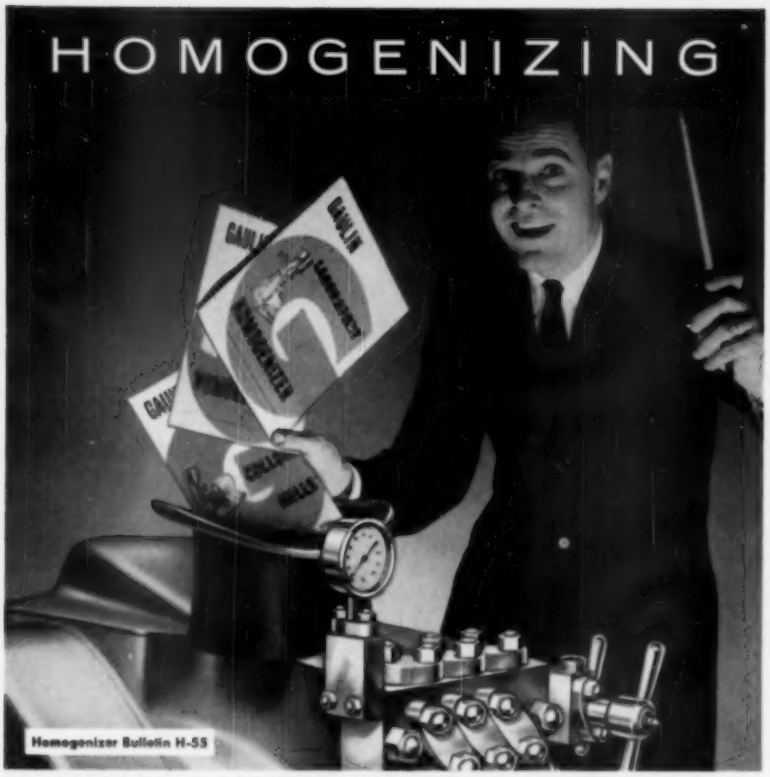
The Associates, a non-profit organization composed of representatives of the food and container industries, cooperates with Quartermaster Corps research workers in developing foods and containers for the Armed Forces. Membership is open to all segments of the food and packaging industries.

The appointment of **Dr. Wolfgang Huber,** an IFT member, as West Coast representative has been announced by Food and Drug Research Laboratories, Inc. He will function in a liaison capacity between the western clientele of the Laboratories and their headquarters in New York. Formerly with Winthrop Chemical Co. and Electronized Chemical Corp., he has been active as an independent consultant since 1953. He has been associated with Stanford University as research associate in radiology and biophysics since 1956. Dr. Huber was among the pioneer contributors to Food Technology on the radiation preservation of foods.

John E. Nicholas, center, Professor of Agricultural Engineering at Pennsylvania State University, and long-time member of IFT, was cited recently for his pioneering spirit in food freezing. The prominent researcher and educator retires July 1. Reading the citation on a plaque honoring Nicholas is Oscar C. Lange, right, of Allentown, Pa. At left is Mrs. Nicholas.

Dr. K. T. Keller

Dr. Karl T. Keller, former director in charge of production and development of Schimmel & Co., A. G. Miltitz, Germany, has joined the chemical research staff of Fries & Fries, Inc. He is well known as an authority in the aromatic field and had served his previous firm for over 20 years. For the past few years, since 1952, Dr. Keller has been chief chemist of Schimmel & Co., Inc. in New York.



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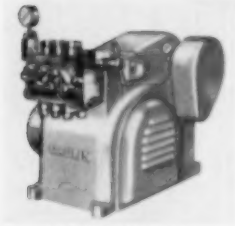

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Arthur J. King, an IFT member, and **John H. Stuart** were honored recently as the two top salesmen of the Vitamin division of Hoffmann-La Roche Inc. Mr. King was presented with the Barell award, given annually to the salesman in the Vitamin division who has achieved the best sales record during the year. Mr. Stuart received the Vice President's award in recognition of his achieving the largest sales increase for the year in the Vitamin division.

B. T. Messina

Blase T. Messina, a member of IFT, has been named as technical service representative to the food industry for Kelco Co., working out of the Chicago office. Mr. Messina was formerly associated with the research department of Krim-Ko Corp. He is a graduate of Illinois Institute of Technology where he participated in the food engineering co-op program of the research division of Armour and Co. In his new position he will provide technical assistance on applications of algin in solving product and processing problems of various foods.

D. H. Nelson

Dewey H. Nelson has been promoted to division manager of the Becco Chemical division of Food Machinery and Chemical Corp., Buffalo, N. Y. **Frederick A. Gilbert,** formerly in that post, has recently been appointed general manager of FMC's new inorganic chemicals department, of which Becco is a part. Mr. Nelson is a graduate of M.I.T., and he has been with Becco since 1947, working first in the special projects department and later in the research department. He also served as midwest district sales manager in Chicago before returning to Becco headquarters.

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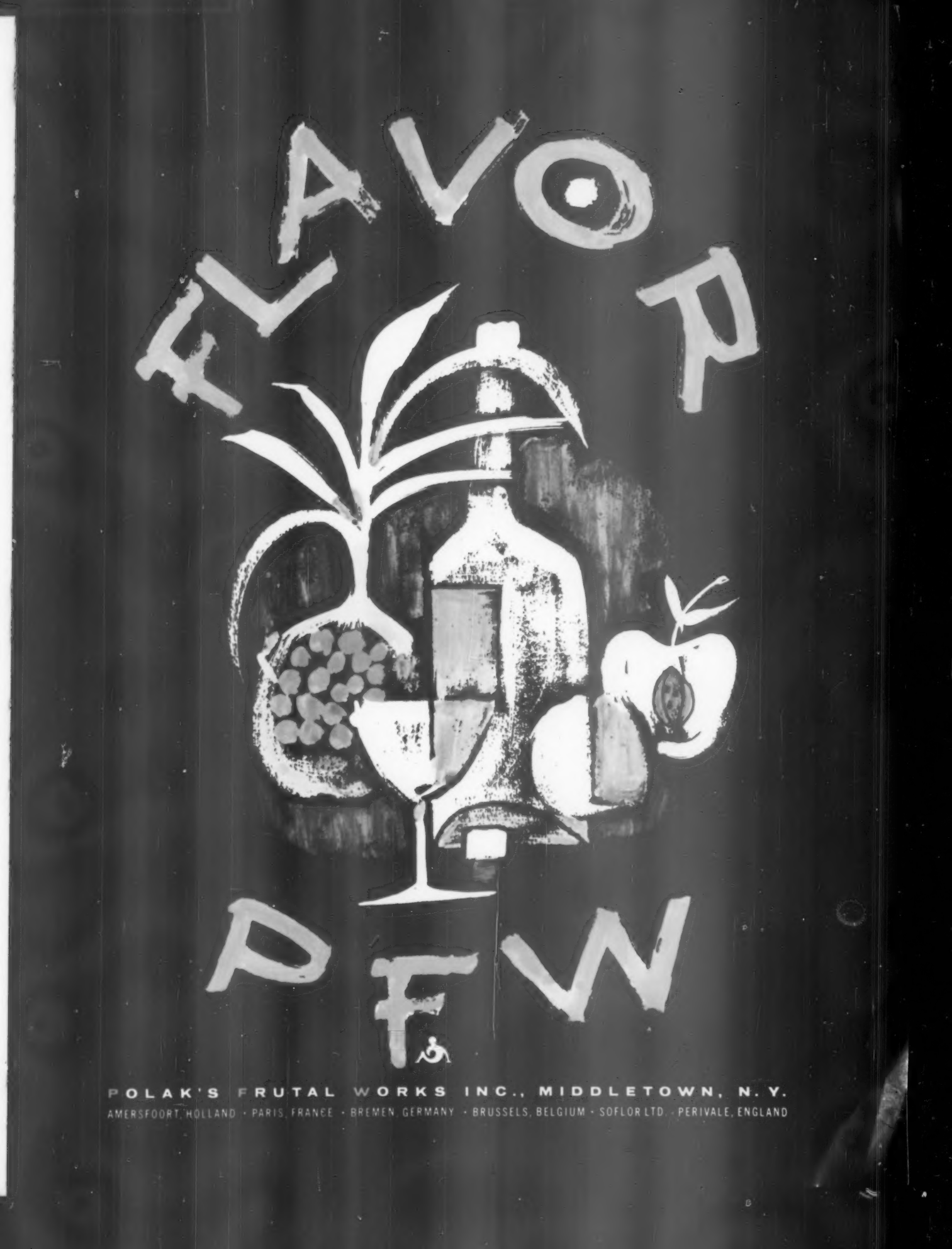

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